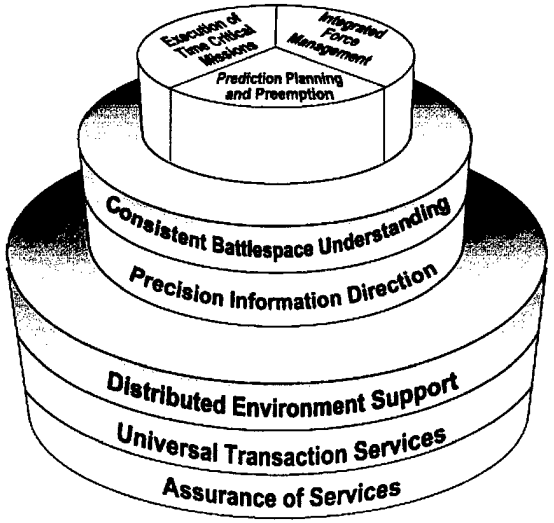

Advanced Battlespace Information System (ABIS)
Task Force Report
Volume V
Grid Capabilities Working Group Results

Director of Command, Control, Communications, and Computers (Joint Staff)

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May 1996

Advanced Battlespace Information System (ABIS)

Task Force Report
Volume V

Grid Capabilities Working Group Results

May 1996

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Dr. H. Frank, ARPA
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Preface

This is Volume V of the final report of the Advanced Battlespace Information Systems (ABIS) Task Force. The entire final report is organized into six separately bound volumes:

I. Executive Summary

II. Major Results

III. Battle Management Working Group Report

IV. Sensor-to-Shooter Working Group Report

V. Grid Capabilities Working Group Report

VI. Supporting Annexes

This volume is the full report of the Grid Capabilities Working Group. It contains an executive summary of the major findings and conclusions and a detailed discussion of the specific areas that were considered by the working group.

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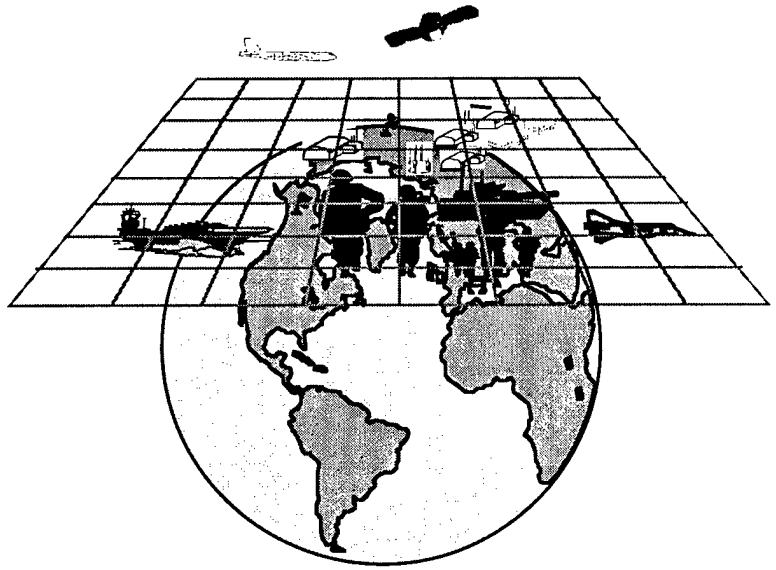
1. Executive Summary

Definition and Scope of the Grid

- An *"Information Environment,"* Comprising a Dynamic, Adaptive Set of Mechanisms, Services, Facilities, and Value-Added Functions That Enable Information and Knowledge To Be Developed and Exchanged Among Users and Systems in Support of Their Missions.
- Composed of Federated Systems and Elements That Can Be Configured and Managed To Suit the Commander's Needs.
- Can Be Projected Globally To Support Multiple Operational Areas.



Definition and Scope of the Grid

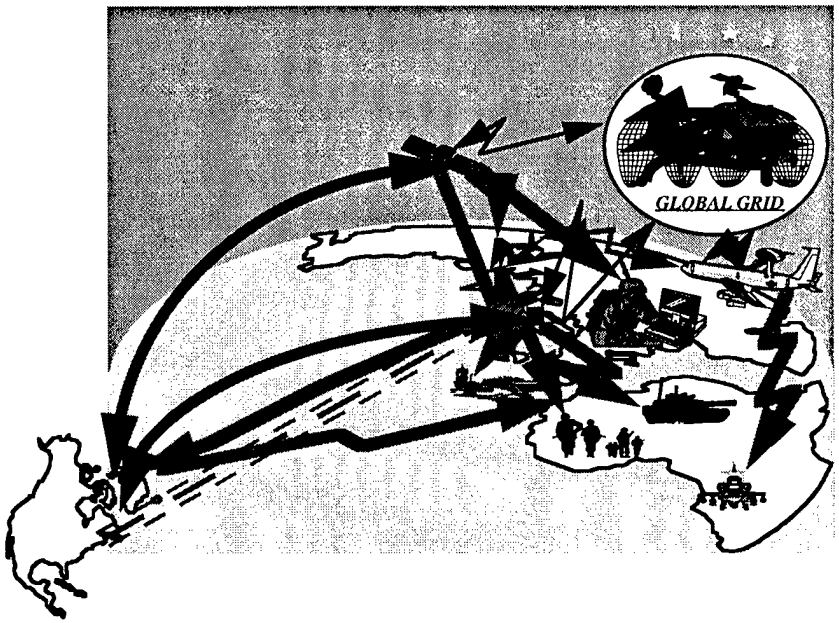
The ABIS Grid is more than a communications network. It is an information environment, including communications, processing, information repositories, and value-added services that provide the users with an ability to find information, to obtain processing services, and to exchange information. The notion of the "infosphere" developed in the C4I for the Warrior concept is a good vision of the type of services that the Grid would provide. The warfighters will be able to connect to this Grid or infosphere anywhere and at any time and will be able to craft their own information environment by selecting the types of services, information, and interfaces that are appropriate to their missions and styles of operation. The Grid will provide connectivity and information that will adapt to changing situations and will be responsive to the warfighter's need for knowledge. It will adapt to the constraints imposed by connectivity at the tactical levels and will be able to organize resources within the global infrastructure to service the needs of the warfighters. It will provide access and security controls and information warfare defenses that are matched to the operational situation, and it will be managed in accordance with operational needs and priorities.

To accomplish this, the Grid will comprise a wide variety of communication links that extend from very wideband terrestrial networks, to varying bandwidth satellite networks, and to tactical networks built on airborne relays, tactical fiber optic links, and tactical radios. The Grid will also contain processing centers, information repositories, management centers, and intelligent applications that manage the services and provide the users with assistance in finding, integrating, and viewing information. In the initial stages, the Grid will integrate existing networks and processing facilities to begin to establish an integrated information environment that spans the existing systems of the services and CINCs. Capabilities will be added in the near term to help manage the total information and the end-to-end services, including extensions to tactical users on the move. Additional capabilities, in the form of automated intelligent agents, will be added to assist the users in finding and retrieving information so that they are not overwhelmed with the massive amount of information and sources available in the Grid.

The dividing lines between what is "in the Grid" or "part of the Grid" and what is a "user's system" connected to the Grid are very difficult to define because the Grid itself derives much of its capability and information from the connected systems. In fact, the specific distinction is not particularly important because the Grid will be a federated system rather than a single entity that is "owned" and managed by a single organization. Various domains within the Grid will be owned by different organizations and will be managed in a way that preserves both the overall integrity of the integrated information and services and the individual organizational prerogatives of the participating organizations. The concept is to establish the federation of systems in a way that matches the warfighters' needs for services as well as their operational concepts and doctrine. The nature of the federation will evolve over time as concepts and technologies emerge and are matured. Initially, the federation is likely to be relatively loose at the tactical levels, where information services are strongly tied to organizations. As the evolution progresses toward a distributed information environment that may become decoupled from the specific command and control hierarchy, the federation is likely to become less domain focused and more strongly integrated within a joint context.

Grid Operational Concept

- Provide Connectivity and Information Services That Allow the Warfighters To Craft Their Own Information Environments
- Support Operations on Short Notice Globally, With Full Support to the Warfighters From Assets Anywhere in the World and With a Small Footprint in the Area of Operations
- Provide Information Services That Allow the Warfighters to Decouple Their Concepts and Procedures From the Constraints Imposed by the "Bandwidth Paradigm"
- Focus on Support to Tactical and Mobile Users, With an Emphasis on Responsive Connectivity and Information Services When and Where They Are Needed
- Provide Direct Sensor-to-Shooter Connectivity and Robust Networking for "Movers"" and "Shooters" in the Highly Dynamic Battlespace
- Embody "Jointness" in All Aspects of Information System Support, From Basic Concepts Through System Design and Operation



Grid Operational Concept

The main purpose of the Grid is to provide warfighters with an ability to craft their own information environments. This means that the Grid services must be available whenever and wherever needed, and in a manner that places minimal burden on the warfighters or on the other systems needed to sustain them. The in-theater footprint needs to be small so that neither the forward deployed forces nor the transportation assets that serve them are stressed by the requirement to deploy and sustain large amounts of equipment or personnel.

The Grid will enable the warfighters to develop concepts and plans without imposing a priori bandwidth constraints on their thought processes. By providing both wideband circuits as well as intelligent management and use of information and processing, the transactions supported by the Grid will emphasize knowledge and deemphasize data, allowing the overall throughput to be reduced to the essential transactions, not simply enormous amounts of information. Smart end-point information management and smart distributed information services will support the warfighters in breaking the bandwidth paradigm.

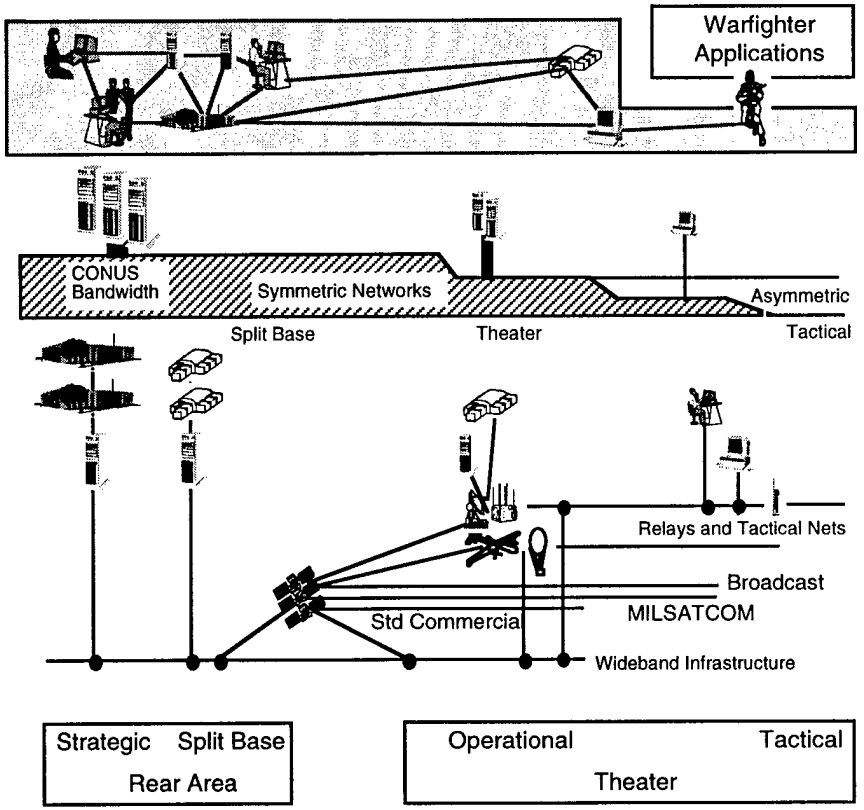
Support for the tactical, mobile users will be emphasized. These users are often the warfighters with the most urgent needs for high-quality, mission-tailored information; and the Grid will focus on bringing the full set of assets to bear to meet those needs.

Finally, the Grid will embody jointness in all aspects. As such, it is conceived as a joint information construct, from the highest levels of command down to the individual combat unit or individual. Information and information services will be structured within the integrated Grid framework in a way that any user, regardless of organization, will have access to information in accordance with his or her needs, constrained only by security and access privileges.

Grid System Attributes

Provide Infrastructure, Services, and Repositories of High-Quality Knowledge in the Grid With Ensured Availability and Responsive Access and Delivery

- Efficient—Not Duplicative. All Available Resources Will Be Brought to Bear, Priority Based on Operational Mission, Sending the Right Information in the Right Form by the Best Means, Just in Time and Just Enough, Broadcast Data Both Globally and in the Theater.
- Flexible—Supportive of Any Force Package and Any Operational Environment. Information and Connectivity Decoupled From Rigid Hierarchies. Information Available As Needed to Whomever Needs It.
- Adaptable—Responsive to Highly Dynamic Changes in Demand. Clear Ability to Redirect Capability to Where Needed, and to Reprogram on the Fly.
- Interoperable—Integrate Across Heterogeneous Communications Networks and Information Processing Systems. Built-in Language Translation to Ensure Interoperability With Coalition Forces
- Robust—Information Warfare Defenses. Offers Management of Infrastructure and Information, With Priority Ordered, Graceful Degradation, and Service Restoral.



Grid System Attributes

The Grid is a networked set of infrastructure, services, and applications that extend from CONUS to wherever U.S. forces operate. It provides the communications, processing, information storage and management, and service access functions that permit warfighters and their systems to receive, exchange, and operate on information essential to their tasks. This figure depicts the layers of capability, building from the communications and computing infrastructure, through the services and information management, and up to the applications. The Grid is dense and proliferated in CONUS and other rear areas, and it thins out as it extends to the tactical forces. In CONUS, the Grid supports numerous facilities, such as command centers, intelligence centers, and sustainment centers (split base, etc.) in several ways. It allows them to connect to sources of information for their own functions, including distributed, collaborative processes. It also allows them to connect to the deployed forces, to be able to project support to the theater without having to be located in the forward area. Within the operational theater, the Grid provides high quality information to the warfighters by means of an integrated set of wideband and narrower band communications. Those integrated communication assets also provide direct user-to-user communications that can be adapted to dynamic user needs on time scales consistent with the mission requirements.

The concept recognizes that economic constraints will be an important factor, and the use of an integrated Grid will serve to reduce unnecessary duplication, and hence reduce cost of ownership. In addition to reducing costs, the efficiency of the integrated system will reflect its greater efficiency in managing information for all warfighters within a single, integrated information environment, not separate stovepipe systems. This means that the best information and the best means to move and process information will be available. Artificial constraints imposed by organizational or domain boundaries will be minimized.

The result will be greater flexibility, both in managing information and in using it. When information is decoupled from the organizational hierarchies, it will be possible to deliver needed knowledge directly to the warfighters and to respond quickly to requests for information. Serial processes often introduce bottlenecks caused by limited throughput or limited knowledge of the availability of information. An integrated information system will bypass many of those limitations.

To serve joint and coalition forces, the Grid will have to be adaptable and interoperable. We cannot determine in advance the specific information architecture or requirements for all operations. The Grid will have to be adapted in real time to meet specific needs. It will have to provide interoperability not only within the U.S. forces but also to coalition forces. This imposes requirements for language, culture, and military procedure translation and for highly adaptable control of information access and information security.

Robustness is a fundamental part of any military system. The Grid will have to be able to operate in the same environments as the forces, with the same degree of survivability. It must be able to protect its information and services from physical attack and from the emerging threat of information warfare. This implies significant capability to defend against those threats and to protect and restore services and information when attacked. The warfighters must be confident in the ability of the Grid to provide high-quality information and services.

Important Grid Capabilities

- Distributed Environment Support:
  - — Provide All Mechanisms and Services Required To Allow the Warfighters To Craft Their C4I Information Environment From the Full Set of Assets Connected Through the Grid, Including the Ability To Establish Distributed Virtual Staffs, To Share a Common Consistent Perception of the Battlespace, and To Construct Distributed Task Teams Among Sensors, Shooters, Movers, and Command Posts.

- Universal Transaction Services:
  - — Provide Warfighters and Their Systems the Ability To Exchange and Understand Information, Unimpeded by Differences in Connectivity, Processing, Language, or Interface Characteristics.

- Assurance of Services:
  - — Provide High-Quality Services That the Warfighters Can Rely On To Be Available Whenever and Wherever Needed, and That Can Be Adapted, Scaled, and Projected To Meet Dynamically Changing Demands and Defended Against Physical and Information Warfare Threats.

Important Grid Capabilities

The three areas listed in this figure define the types of services that the Grid needs to provide.

The Grid establishes a distributed, networked environment of systems and users. Within DoD, we strive for a common operating environment, but even if we achieve this, we will still have to cope with the heterogeneity of the commercial world and of our allies and potential coalition partners. To achieve our ends, the Grid will have to be conceived within a context of massive heterogeneity. It will have to be able to deal with information distributed around the world in many varying formats, in different languages, with different syntax, and in multiple types of presentations. Because we also need to be able to work with various organizations and people, the language and cultural problems again arise. Our objective is to present a common picture to all users, based on the best information available from the massive, distributed, heterogeneous set of resources. We also need to provide distributed, virtual workspaces where collaborative processes can take place among users with vastly different types of interfaces and different abilities to connect into the workspace. The Grid will need to provide information conditioning, mediation, interpretation, and presentation services to make this possible.

Transactions are the mechanisms by which the warfighters will receive and exchange information. This implies ability to transmit, receive, and interpret information from another person or system. Often we think of communications as the only element of the transaction, but the packaging and interpreting of the information are just as important. As we move more and more toward digital and automated processes, the communication part of the problem is being eclipsed by the packaging and interpretation parts. Universal transaction support means that we will be able to move information from wherever it exists, in whatever form it exists, to wherever it is needed, in whatever form it is needed. The goal is a universal transaction mechanism that is independent of the particular links or networks and that can serve any set of users, not just the limited set for which a particular link or network may be designed. The universal mechanism, whether it is ATM cells or something else, should be able to move from link to link and from network to network without requiring translation, conversion, or any other form of processing other than the modulation and signaling native to the particular links or networks. In the midterm, the proliferated data link standards and protocols will be reduced to a few, and in the longer term the information packages and transaction mechanisms will be further reduced toward the end objective of a common, end-to-end, universal mechanism.

Finally, the users must be confident that the services and information provided by the Grid will be available when needed and will be of sufficient quality and integrity to support them. Assurance of service must be commensurate with the warfighter's expectations and needs for those services. Clearly, we cannot assure 100 percent availability and reliability. That is a physical and mathematical impossibility; but we do need to ensure a level of service that is sufficiently high that it does not impose a weak link in the C4I chain supporting the deployed forces. There are two parts to this assurance. One is confidence in availability— that the services will be extended to the warfighters in their areas of operation and will not be interrupted by failure, battle damage, or preemption by higher authorities. The second is the assurance of the integrity and quality of the information itself. When a warfighter uses organic systems and services, he or she feels confident in knowing the specific sources of information or the specific characteristics of the system. When nonorganic systems and services are used, the feeling of confidence may not be as great. One of the challenges in implementing the Grid is to provide features that will allow the warfighters to understand and trust the services and the information. Part of this challenge will be to protect the Grid from physical and information warfare threats and to provide mechanisms to restore services and information when damage is sustained.

Key Opportunities for Near-Term Demonstrations

- Defensive Information Warfare:
  - — Near-Term Demonstration of Capability to Link Existing Nodal and Link Protective Devices to Establish an Initial IW Defensive Surveillance and Tracking Network for Blatant Intrusion Attempts Into the Grid. Application of Existing Guards, Firewalls, and Other Access Control Devices. Adaptation of Existing Correlators and Trackers Used in Surveillance and Warning Systems.
  - — Mid- and Long-Term R&D and Demonstrations to Establish an IW Surveillance, Tracking, and Control System That Can Extend Throughout the Grid. Extension of Near-Term Demonstration to Advanced Nodal and Link Protection Devices. Application of Computer Security Monitoring and Network Probe Devices as Augmentation to the Initial Suite of IW Intrusion Sensors. Application of Artificial Intelligence for Enhanced Capability To Recognize Patterns of Activity Within the Grid. (This Recommendation Is a Part of the Recommended IW Battle Management in Volume III.)
- Distributed Situation Assessment:
  - — Near-Term Demonstration of Capability to Find, Retrieve, Integrate, and Present High-Quality Information From Massive, Heterogeneous, Distributed Information Sources, Such as Those Serviced by BADD and GBS. Application of Metadata and Linking Techniques To Create a Consolidated Information Layer. Application of Correlators, Multihypothesis Trackers, Constraint-Based Reasoning, and Evidential Reasoning Tools To Identify, Tag, Track, and Resolve Ambiguities and Conflicts Among the Information Domains. Application of Visualization Tools and Techniques for Cognitive Support to the Warfighters.
  - — Mid- and Long-Term R&D and Demonstrations To Develop Automated Capabilities for Consistency Management and Automated Aids for Knowledge-Based Information Discovery and Retrieval. Increased Emphasis on Knowledge-Based Information Integration and Presentation. Increased Emphasis on Advanced Visualization Techniques and Advanced Automated Reasoning Tools.
- Robust Tactical/Mobile Networking:
  - — Near-Term Demonstration of Capability to Rapidly Reconfigure Connectivity and Adapt Transactions To Meet Users' Needs Needs for Content, Quality, and Timeliness in Dynamic Battlespace Environments. Application of Coding and Compression Techniques Such as Progressive JPEG and Radiant Tin. Application of User Profiles and Out-of-Band Orderwires To Manage Network Reconfiguration. Application of Adaptive, Conformal Array Antennas To Improve the Connectivity to Users on the Move. Application of Asymmetric Transaction Protocols To Provide Means for Dynamic Management of User Profiles and Access Privileges, and To Support Interactive User Pull.
  - — Mid- and Long-Term R&D and Demonstrations To Add Advanced Commercial Techniques for Signal Conditioning and To Introduce Automated, Adaptive Conditioning at Discontinuity Points in the Network. Development and Integration of Automated Decision Support and Artificial Intelligence Tools for Network Reconfiguration.

Key Opportunities for Near-Term Demonstrations

The three demonstration and R&D areas listed here are focused on the three high-priority thrusts shown in the preceding figure.

Defensive information warfare is an embryonic warfighting area in which significant gains can be made by applying existing systems and tools in nontraditional ways. This demonstration and its R&D area are proposed to start the movement toward a highly capable IW defensive network by using "resources of opportunity" in an intelligent, deliberate manner.

Distributed situation assessment is a proposed first step in bringing the full Grid information to bear on the operational problem. Within 1 or 2 years, the warfighter will have available an enormous amount of information through mechanisms such as the Global Broadcast and the terrestrial ATM/SONET networks. The main problem will be coping with this "glare of war" in place of the information-poor "fog of war" of the past. In addition, buried in the mass of information will be inconsistencies, ambiguities, errors, and uncertainties. As the mass of information increases, the mass of "noise" and confusion also increases. The challenge is to be able to make best use of the wealth of information, using technology as the means to filter, integrate, assess, package, and present knowledge, not just deliver information.

Tactical/mobile networking is probably the most important part of seamless communications that needs to be worked from a joint perspective. The proposed demonstration and R&D would build on existing links and networks and attempt to achieve a high degree of self-adaptation in both the management of connectivity and the conditioning of transactions to meet the users' needs.

Additional Demonstration Opportunities

- C4I for the Grid:
  - — Near-Term Demonstration of Visualization Tools To Project the Capabilities of the Communication Networks Onto Operational Plans and Missions. Application of Current Management Systems To Provide End-to-End Visibility of Connectivity Through Multiple Interconnected Networks. Application of Operational Planning and Simulation Tools To Project Network Requirements.
  - — Mid- to Long-Term R&D and Demonstrations of Anticipatory System Management, Including Communications and Processing. Extension of the Automated Planning and Simulation Tools To Provide Realistic Projections of Grid Demand. Extensive Use of Visualization Tools Integrated With the Operational Planning Systems To Provide Mission Supportability Information to the Commanders and the C4I System Managers.
- Joint, Early Entry C4I for Rapid Force Projection:
  - — Near-Term Demonstration of the Ability To Conduct Just-in-Time, Just-Enough Planning To Allow Force Deployment Before Completion of All Plan Details. Application of Distributed, Collaborative Planning and Wide Area SATCOM to Allow Participation by Staffs On-the-Move and in Flight in the Collaborative Sessions. Application of Automated Planning Tools and Uncertainty Management Tools To Manage the Critical Linkages Between Operations, Logistics, and Transportation Plans.
  - — Mid- to Long-Term R&D and Demonstrations To Extend the Initial Efforts to the Execution Phase. Development of "Rolling Plans" for Air and Gunfire Support, With Real-Time Refinement Coordinated With the In-Flight Early Entry Battle Staff. Use of Automated Alarms and Triggers To Manage Uncertainties and Assumptions.
- Information Security:
  - — Near-Term Demonstration of Automated Interfaces Between U.S. and Coalition Forces, Using Existing Gateway and Compartmented Mode Workstation Capabilities
  - — Mid- to Long-Term R&D and Demonstration of Advanced Multilevel Information Security and Adaptive Access Control for Both Joint and Combined Forces.

Additional Demonstration Opportunities

The three areas listed here are critical factors in the evolution toward the Grid.

C4I for the Grid is a proposed demonstration and R&D area to establish responsive, dynamic management across the interconnected domains and to provide the warfighters with visibility into the operational implications of the Grid's capabilities. The long-term objective is to provide anticipatory management that allows the Grid to adapt in near real time to operational needs and to provide strong coupling between Grid management and operational planning by using advanced cognitive support tools. In the near term, the emphasis would be on demonstrating the ability to integrate management across domains, to use commercial and special-purpose DoD products to condition information to match the transport networks, and to use existing visualization and modeling tools to advise the operational users of the Grid's ability to support their missions.

Joint, Early Entry C4I for Rapid Force Projection is an area intended to demonstrate the ability of the Grid to support a very stressing operational situation by leveraging the distributed information, the seamless networking, the information management and integration tools, and available cognitive support tools. This demonstration area would call into play most of the features of the Grid and would demonstrate the ability to support operations that are not supportable by the aggregate of existing, independent systems and services without the Grid.

Information Security is one of the potential "show stoppers" for which some degree of capability can be implemented by existing devices. The intent is initially to assemble a suite of information security and access control capabilities that have been independently demonstrated to establish a prototype package that can be applied in ad hoc situations. Subsequent effort would expand on this initial capability, moving toward the type of multilevel, agile, adaptive security and access control needed in the future.

Key Observations

- The Grid Is an Intelligent, Distributed Information System
  - — Robust, Adaptive Communications
  - — Processing Support for Locating, Integrating, and Delivering Knowledge

- The Grid Is a Federated, Heterogeneous System-of-Systems
  - — Ownership and Management of Information and Services According to the Needs and Prerogatives of the Participants
  - — Functionality Extends to All Types of Users in Joint and Combined Operations
  - — Participants May Include Civil, Commercial, and Foreign Organizations

- The Grid Provides Information Services Matched to Tasks That Are Responsive to the Warfighters' Dynamically Changing Needs
  - — Decoupling of Information Management From Force Management
  - — Adaptation To Support Tactical Task Teams and Other Real-Time Needs

- Information Protection Moves From the Old Paradigm of Risk Avoidance to the New One of Risk Management
  - — Risk Mitigation Balanced With Needs for Functionality and Versatility
  - — C4I and Defense of the Grid Consistent With Projected Operational Environments
  - — Backup and Restoral Consistent With Operational Priorities

Key Observations

As the figure shows, the vision of the ABIS Grid includes several important features.

First and most foremost, the Grid is an intelligent information system environment comprising communications and computing elements that establish an integrated, distributed capability to acquire, manage, and deliver information and services suited to the warfighters' needs.

Second, it is an environment that deliberately intends to cope with heterogeneity as one of its basic tenets. It recognizes from the onset the need to accommodate wide variations in the types of users, applications, and information that will be part of the joint and combined operations of the future. This does not mean that DoD should not strive for the highest degree of commonality and standardization that is practical. It only means that there will always be heterogeneity, and the Grid must cope with that heterogeneity and make it transparent to the users. In addition to being a heterogeneous environment, the Grid is a federated system. It will be composed of facilities, applications, and information that are owned and managed by various organizations within some set of rules and procedures that allow it to operate as an integrated entity. This implies a degree of shared and collaborative management that extends far beyond anything envisioned in today's interoperating systems.

The third feature is a very important one. The Grid needs to be responsive to the warfighters' needs and preferences. Information services are at the heart of the revolutionary concepts for C2 embodied in ABIS, and those services must be adaptable to fit the warfighters' concepts and practices. Current C4I systems are often rigidly designed to instantiate processes as defined by current concepts and practices. This is too constraining for future operations, where the situations and force mixes must be flexible to meet changing demands. Traditional coupling of targets, sensors, weapons, and command posts will be replaced with near real-time, dynamic formation of tactical task teams suited to the situation rather than to the traditional organizational structures. These teams may exist for long periods or for very brief engagements. Information systems and services will need to be tailored to suit the wide variety of operational needs. Information will have to be decoupled from the C2 hierarchy serving as a general purpose resource to be directed as appropriate.

The final observation in this figure focuses on the issue of defensive information warfare and information protection. ABIS recognizes that the paradigm has changed and will continue to evolve from the old one of risk avoidance to the new one of risk management. Because of the need to balance capability and flexibility with protection and cost, an approach toward risk acceptance, mitigation, and management is emerging that is fundamental to the vision of the Grid. The goal is to provide enough security and protection for the systems and services to be useful as well as sufficient restoral and backup capability to provide the warfighters with ability to continue to operate even when the Grid sustains damage.

Major Challenges

- Evolution of Operational Concepts and Technical Approaches That Respond to the Technology Revolution and the Revolution in Military Affairs
- Graceful Degradation, Backup, and Restoral Capabilities To Ensure Warfighters Essential Levels of Support
- Timely and Orderly Movement From the Current Baseline Systems to the Objective System With Significant Operational Payoff at Each Step
- Balancing Technical and Operational Risk With Potential Payoff and Cost
- Defensive Information Warfare Capabilities
- Management of Federated Systems

Major Challenges

The challenges define areas where work is needed to change operational concepts, technical approaches, and system acquisition processes. Change will have to occur over time, so that each successive increment is brought into the baseline of concepts, doctrine, and systems to establish a foundation for the next increment. This leads to the next figure, which identifies important issues related to the objectives and challenges.

Important Issues

- To Be Worked at DoD Policy Levels
  - — Defensive Information Warfare Strategy, Roadmap, and Technology Plan
  - — Clarification of Guidelines, Caveats, and Processes for Applying Commercial Products and Services
  - — Level of Investment Versus Need for Defensive Information Warfare, Information Management, and Services Management
- To Be Worked by the Implementation Community
  - — Increased Emphasis on Capabilities and Operational Concepts To Support Tactical Forces on the Move
  - — Coordination of Technical Approaches Across DoD
  - — COTS Versus GOTS Versus Development
  - — Interoperability Across Legacy Environments and Emerging Systems
- To Be Worked by the Planning and Management Organizations
  - — Migration From Current Baseline Systems to ABIS Objective
  - — Effective DoD Participation in Industrial Standards Organizations
  - — Spectrum and Frequency Management

Important Issues

Three categories of issues are listed here: those that require work at policy levels in DoD, those that require work by the implementation community, and those that require work by the planning and management organizations. These are clearly not the only issues in implementing the Grid, but they are ones that were highlighted by the Grid Working Group during the study and at the final ABIS off-site meeting in February 1996.

The policy issues are particularly important because they address the guidelines that DoD needs to establish to coordinate and manage objectives and investments. The best way to achieve the vision is to make clear the specific objectives and goals so that each participant can align programs and initiatives with the common strategy. Shared knowledge of the investment strategy is the strongest mechanism to cause such alignment to occur.

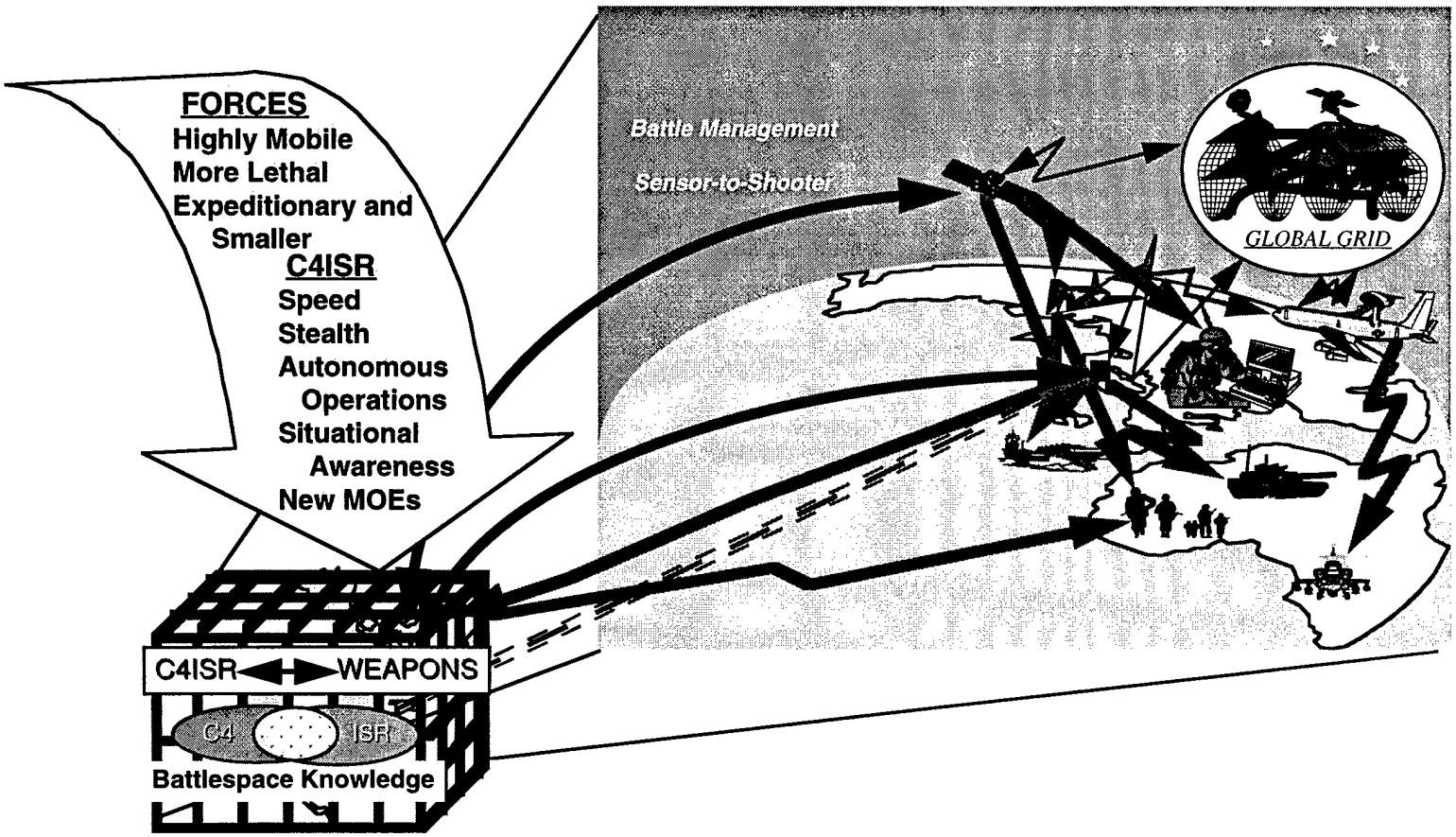
Implementation issues are centered on coordinating the technical approaches and ensuring that DoD takes full advantage of the growing commercial marketplace for commercial technologies. The general view of COTS products as the panacea is becoming shaded by the reality of licensing fees and other features related to COTS, but the clear need is to expand the use of these commercial products and services and to find ways to do this cost effectively and in concert with the rapid evolution and obsolescence of commercial technologies. The acquisition community will need to adapt commercial products to the needs of the tactical forces and to add essential military features that the commercial products may not support. This may involve acquisition of "80-percent" solutions based on user trials and evaluations, or the development of specific essential capabilities that the users decide are worth the investment.

Planning and management organizations will have to address the issues regarding evolution from current systems and concepts. The items listed in this area are representative of some of the most critical ones where work is needed. Migration of the current systems needs to be balanced with a clear vision of the end of life for those systems and a clear determination of how much to invest in improvement rather than replacement. Migration also implies a need for forward compatibility and interoperability so that the legacy systems can continue to operate as the new systems are introduced. In the past, the approach was to demand backward compatibility, but emerging concepts for revolutionary technology insertion ("leap frogging") may require a change in concept to relax some of the constraints on the new systems and to provide "forward compatibility fixes" that support the legacy systems. The second item notes a need for DoD to be active in the international standards arena. It is important to make DoD needs and preferences known and to influence emerging standards where necessary and practical. Participation in the commercial standards bodies will also provide insight into directions that the commercial world is taking, so that advanced planning and R&D can focus on those directions. The final item, spectrum and frequency management, refers to the continued erosion of DoD ownership and control of the electromagnetic spectrum as well as DoD reliance on commercial services subject to national and international regulation and control. Any deployment of U.S. forces in the future will certainly have to contend with national and international regulations and licensing rules that are imposed on the commercial carriers that will provide essential services, and on the U.S. military systems that use the spectrum under the jurisdiction of national spectrum control authorities. The Grid is a distributed system that relies on wideband communications, and these issues are fundamental to the capability of services globally.

2. Results

- Operational Context
- Broad Concepts
- Important Grid Capabilities
- Mapping of Current S&T Program
- Time Phasing of Operational Demonstrations and Technology Expectations
- Conclusions

"ABIS Vision" Into the 21ST Century



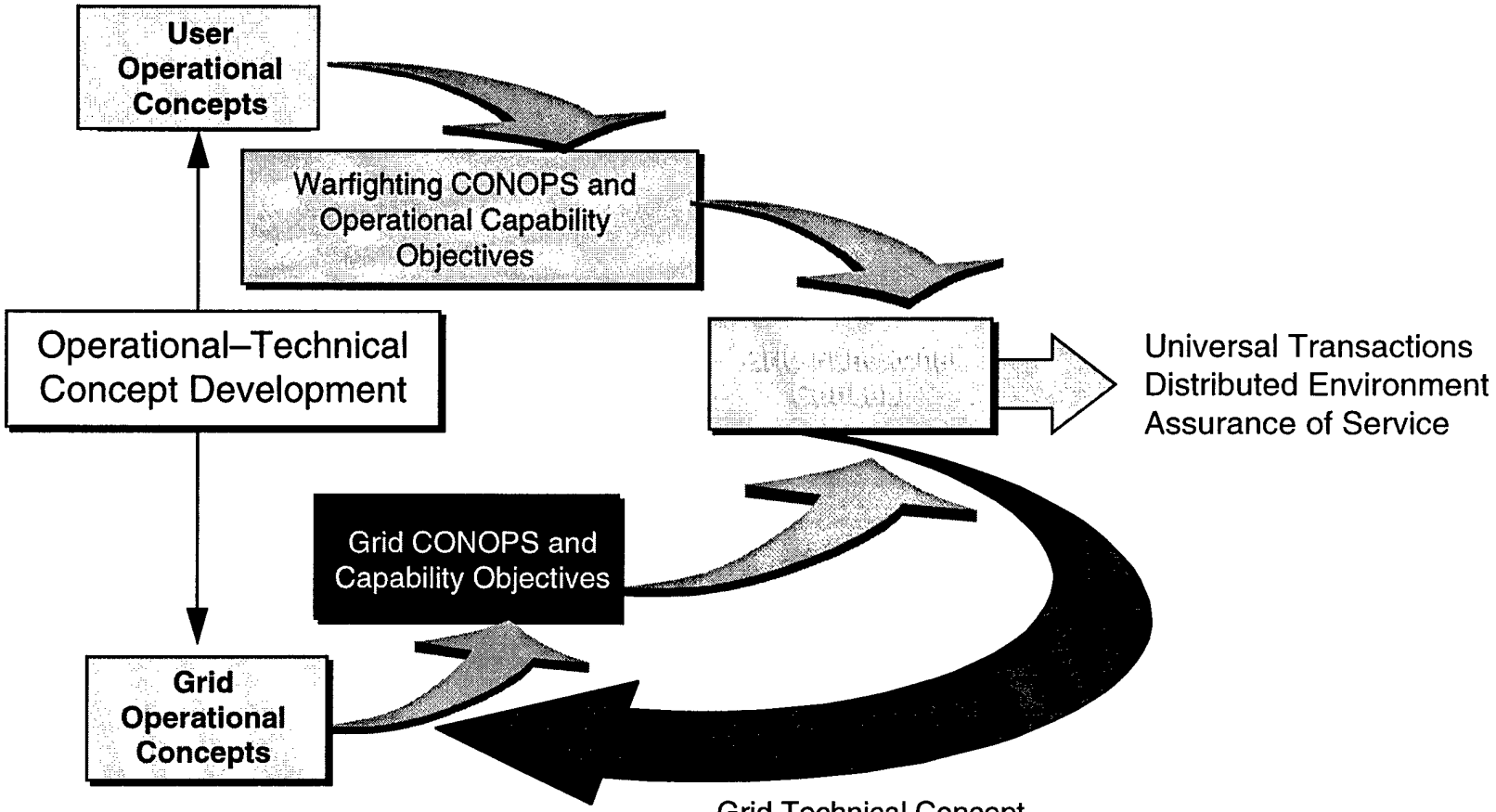
Overarching Objectives

- Provide Connectivity and Information Services That Allow the Warfighters To Craft Their Own Information Environments
  - — By "Unbundling" Information From Applications and Processes
  - — By Using Automated Intelligent Agents To Help Find, Integrate, and Interpret Information
- Eliminate the "Bandwidth Paradigm" in C2 Concepts and Systems
  - — Use Smart End-Point Processing To Reduce the Loads on Communications
    - » Knowledge Versus Data
    - » Just in Time, Just Enough
  - — More Reliance on Fiber: Free SATCOM Capacity for Tactical Use
- Focus on Support to Mobile Users
  - — Decouple Information Flow From Rigid Organizational Hierarchies
  - — Match Communications to the Asymmetric Needs—Smart Push to Warfighters
  - — Provide Automated, Intelligent Network To Adapt Services To Tactical Warfighter Needs
- Allow More Direct Sensor-to-Shooter Coupling
  - — Flatten Process for Assembling and Moving Information From Sources to Users
  - — Distributed, Concurrent, and Adaptive Information Access and Dissemination
- Embody Jointness in All Aspects of Information Support, Including RDT&E
  - — Tools and Decision Support To Select the Emerging Technology "Gems"
  - — Tools and Processes To Expedite Movement from "State-of-the-Shelf" to the Field

Principal Drivers

- Ability To Support Operations on Short Notice, Globally
- Interoperability and Modularity To Match Joint/Combined Forces
- Cost Containment—Derive Capability from Shared Resources
- Flexibility To Support Joint, Combined, and Coalition Operations With Wide Variations of Participants, Systems, and Procedures
- Adaptability To Respond to Changes in User Demand and Grid Capability
- Ability To Integrate Across Heterogeneous Communications Networks and Information Processing Systems
- Ability To Provide User-Friendly and Timely Access to Information From All Available Sources
- High Assurance and Confidence in Service Availability
- Robust Management of Infrastructure and Information, With Priority-Ordered, Graceful Degradation, and Service Restoral
- Robust Information Warfare Defenses

Grid Traceability to Operational Concepts



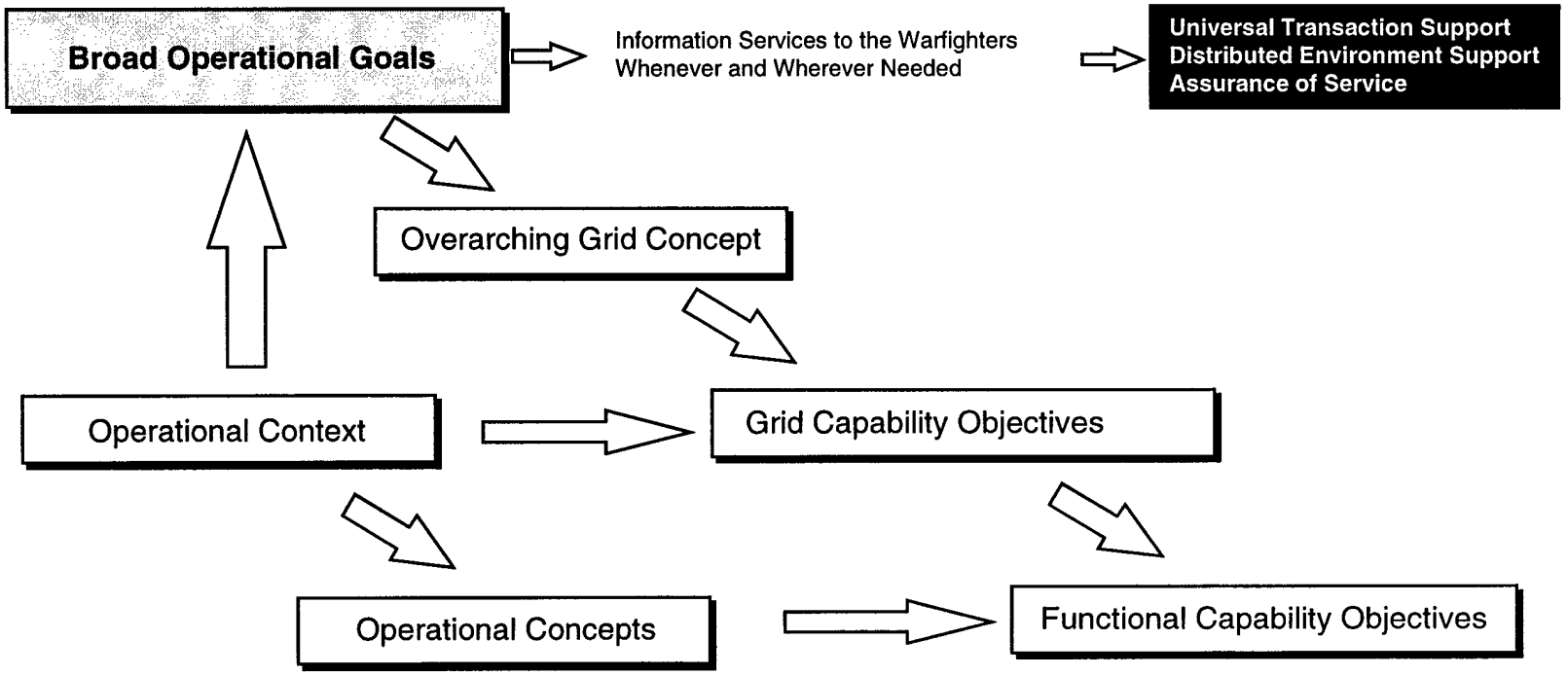
OPERATIONAL CONTEXT

- Operational Context
- Broad Concepts
- Important Grid Capabilities
- Mapping of Current S&T Program
- Time Phasing of Operational Demonstrations and Technology Expectations
- Conclusions

Definition and Scope of the Grid

- The Grid Is an "Information Environment," Consisting of a Dynamic, Adaptive Set of Mechanisms, Services, Facilities, and Value-Added Functions That Enable Information and Knowledge To Be Developed and Exchanged Among Users and Systems in Support of Their Missions.
- The Grid Comprises Federated Systems and Elements That Can Be Configured and Managed To Suit the Commander's Needs.
- Grid Capabilities Can Be Projected Globally To Support Multiple Operational Areas.

Developing the Capability Objectives



Broad Operational Objectives

- Distributed Environment Support:
  - — Provide All Mechanisms and Services Required To Allow the Warfighters To Craft Their C4I Information Environments From the Full Set of Assets Connected Through the Grid, Including Ability To Establish Distributed Virtual Staffs, To Share a Common Consistent Perception of the Battlespace, and To Construct Distributed Task Teams Among Sensors, Shooters, Movers, and Command Posts

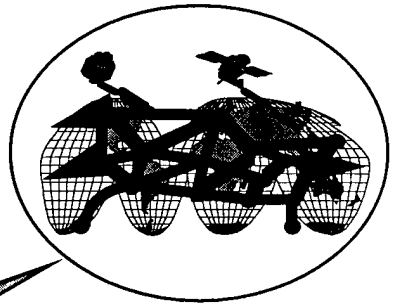
- Universal Transaction Services:
  - — Provide Warfighters and Their Systems the Ability To Exchange and Understand Information, Unimpeded by Differences in Connectivity, Processing, Language, or Interface Characteristics

- Assurance of Services:
  - — Provide High-Quality Services That the Warfighters Can Rely on To Be Available Whenever and Wherever Needed, That Can Be Adapted, Scaled, and Projected to Meet Dynamically Changing Demands and Service Capacities, and That Can Be Defended Against Physical and Information Warfare Threats

Advanced Battlespace Grid

Where We Are

- Lack of Modular Plug-and-Play
- Limited Ability to Project Wideband Networks Globally
- Lack of User Confidence
- Lack of IW Sensors (Indicators and Warning)
- Limited Ability to Support Multilevel Security



C4ISR ↔ WEAPONS

C4 ISR

Battlespace Knowledge

200 x 200 Cube

Global Grid
Universal Transaction Services
Distributed Environment Support
Assurance of Service

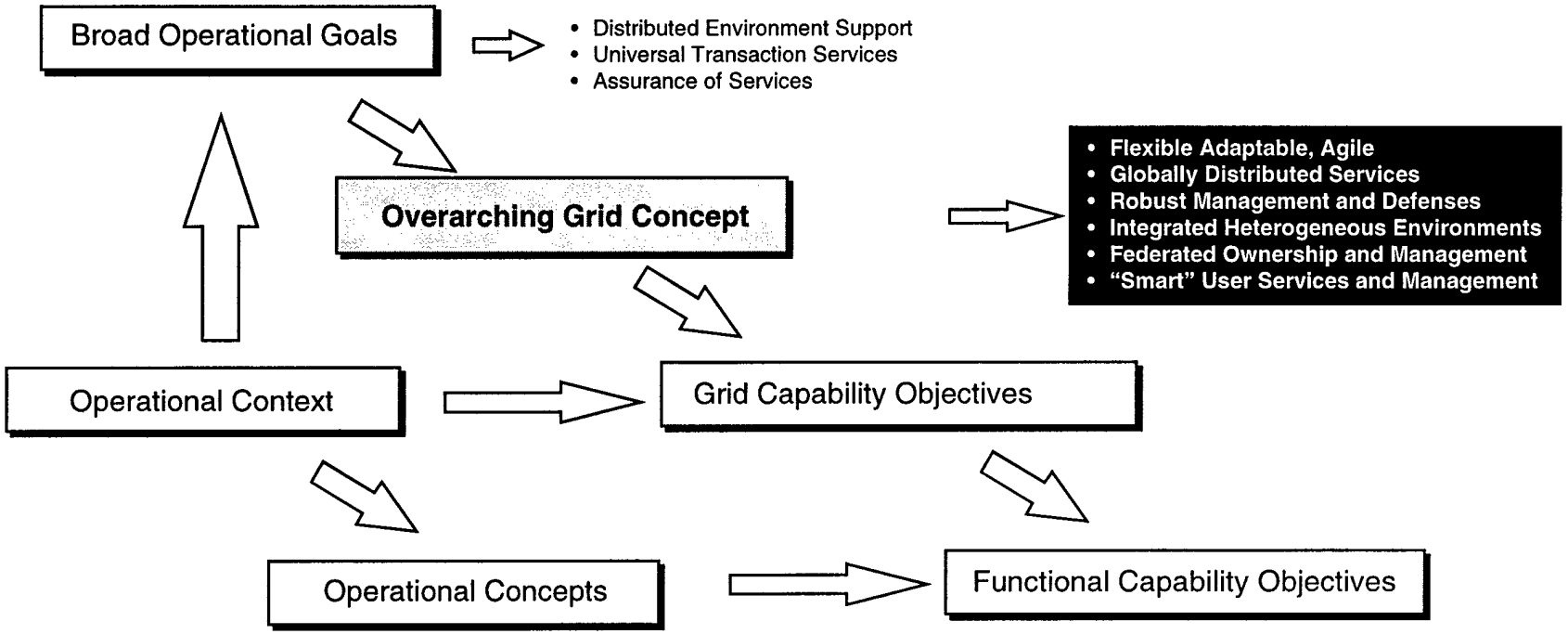
FORCES
Highly Mobile
More Lethal
Expeditionary and
Smaller

C4ISR
Speed
Stealth
Autonomous
Operations
Situational
Awareness
New MOEs

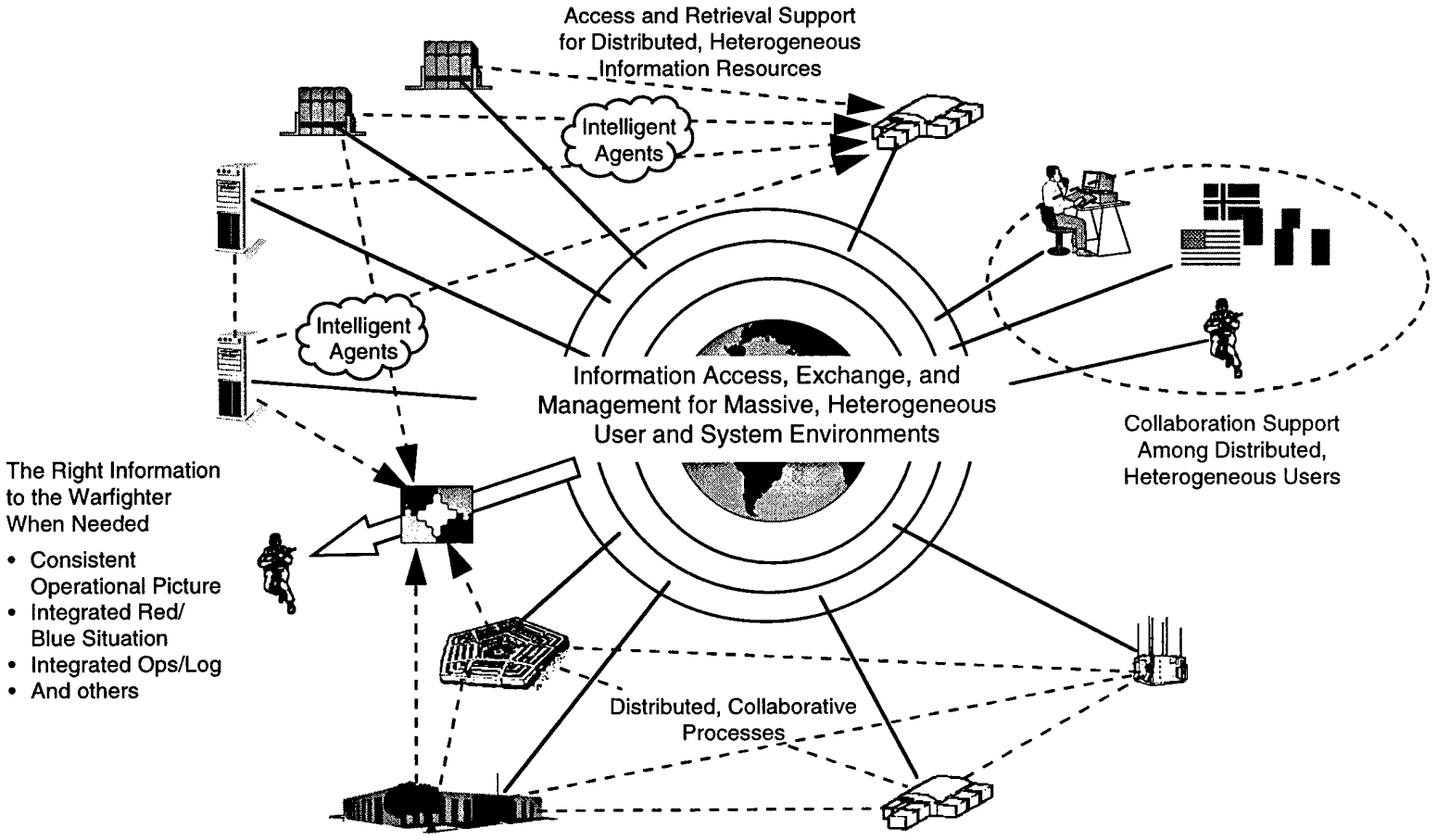
Where We Are Heading

- Warfighter Crafts Own Information Domain
- Eliminate "Bandwidth Paradigm"
- Support to Mobile Users
- Closely Couple Sensor and Shooters
- Systems "Born Joint"

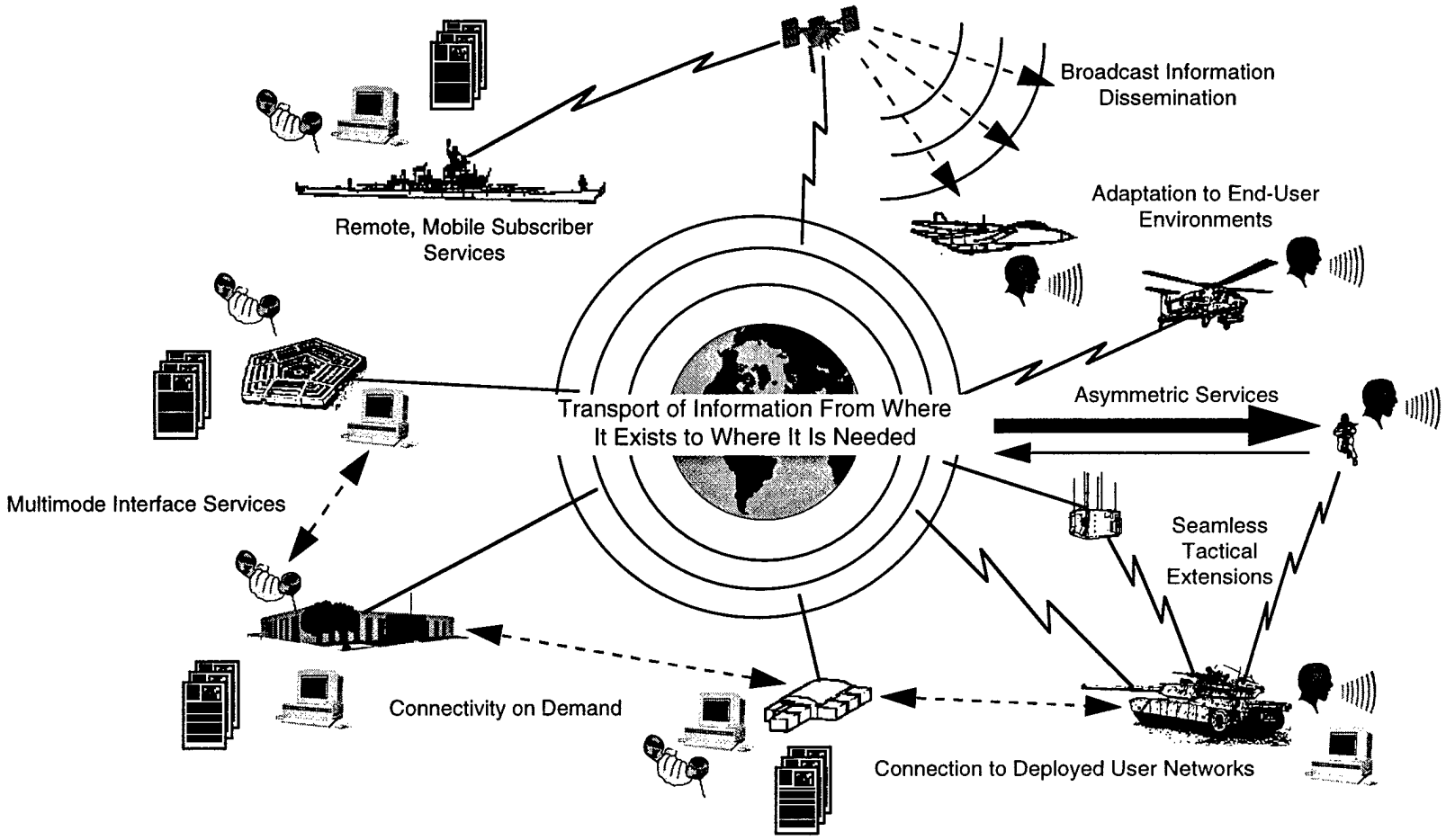
Developing the Capability Objectives



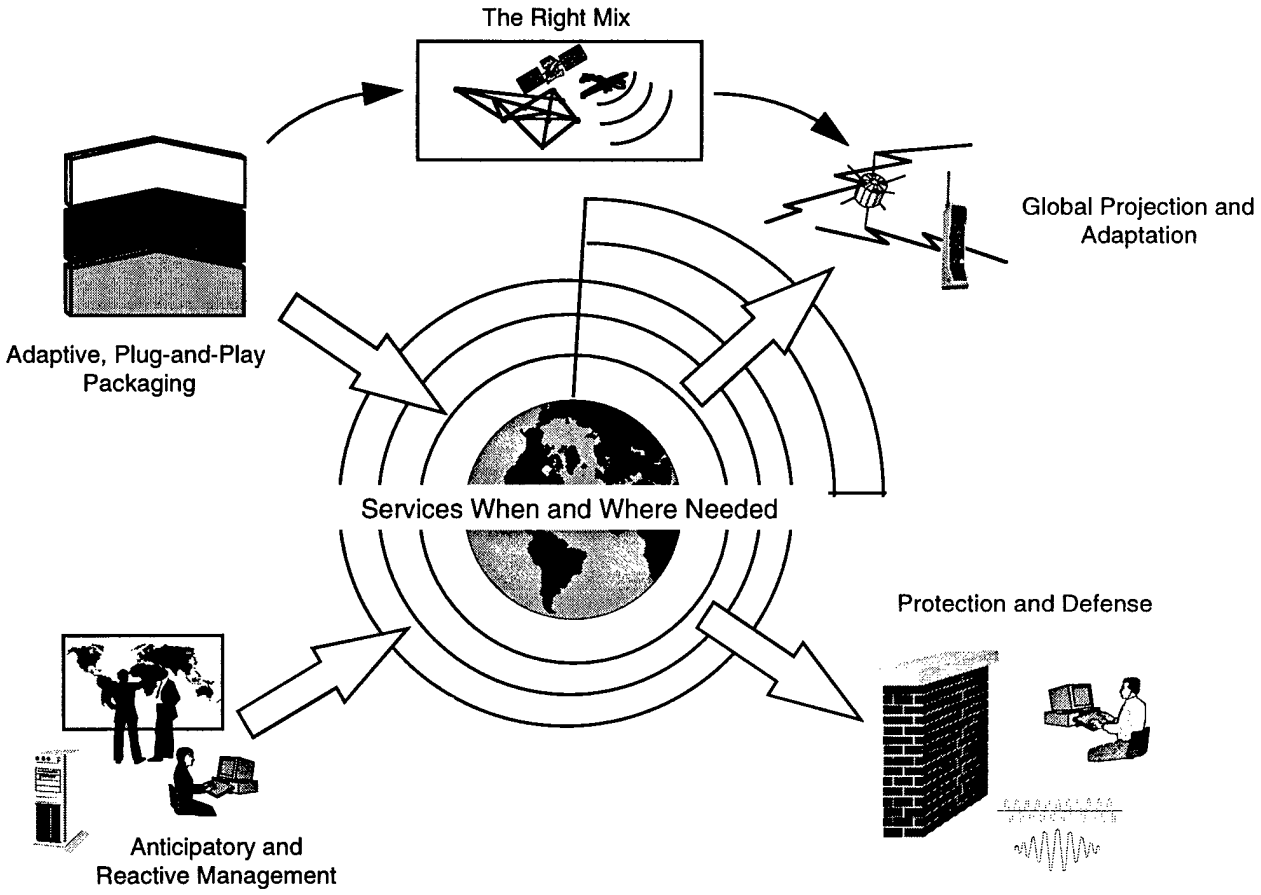
CONOPS for the Grid
Distributed Environment Support



CONOPS for the Grid
Universal Transaction Services

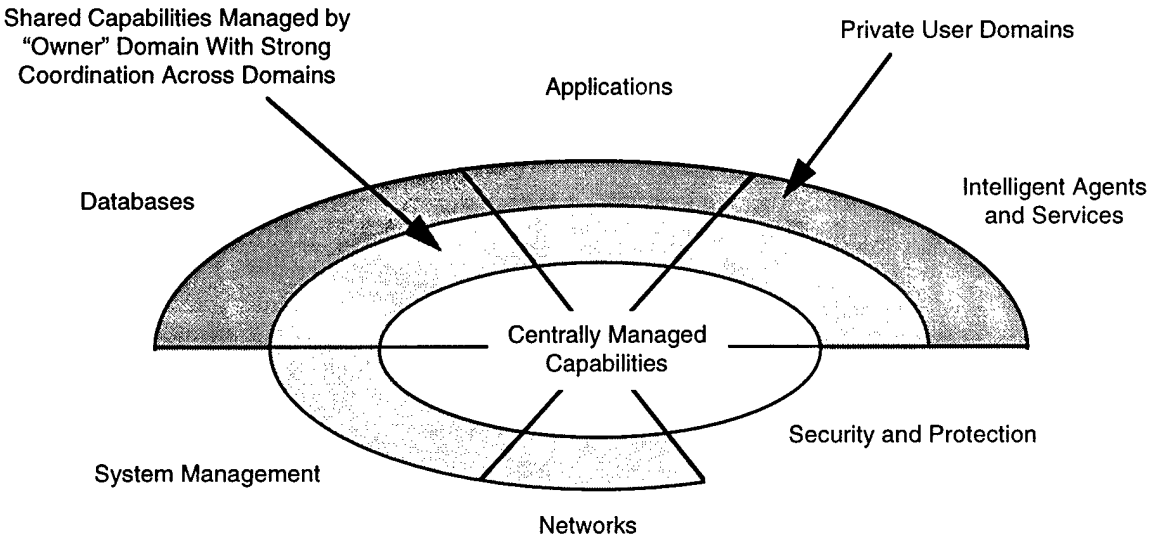


CONOPS for the Grid
Assurance of Services

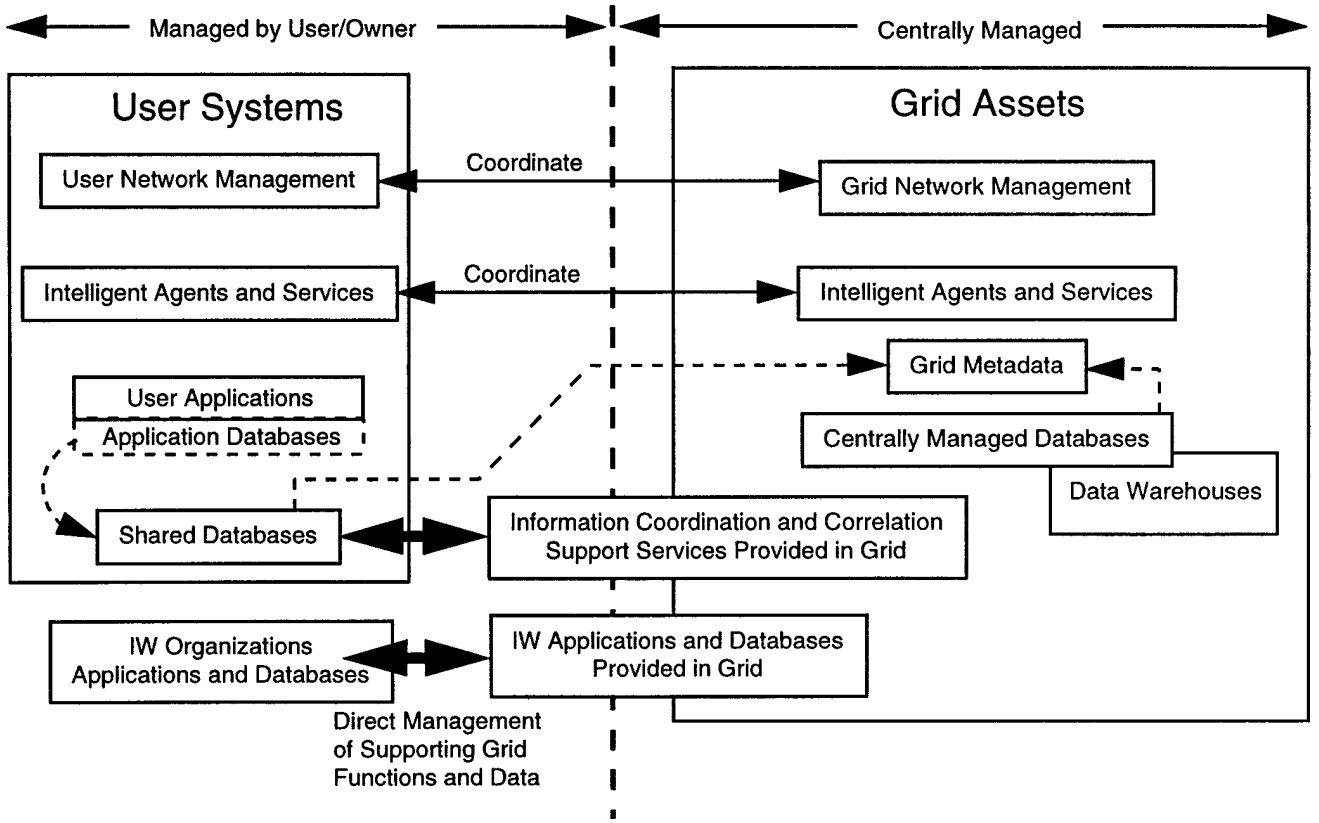


CONOPS for the Grid
Scope, Ownership, and Management

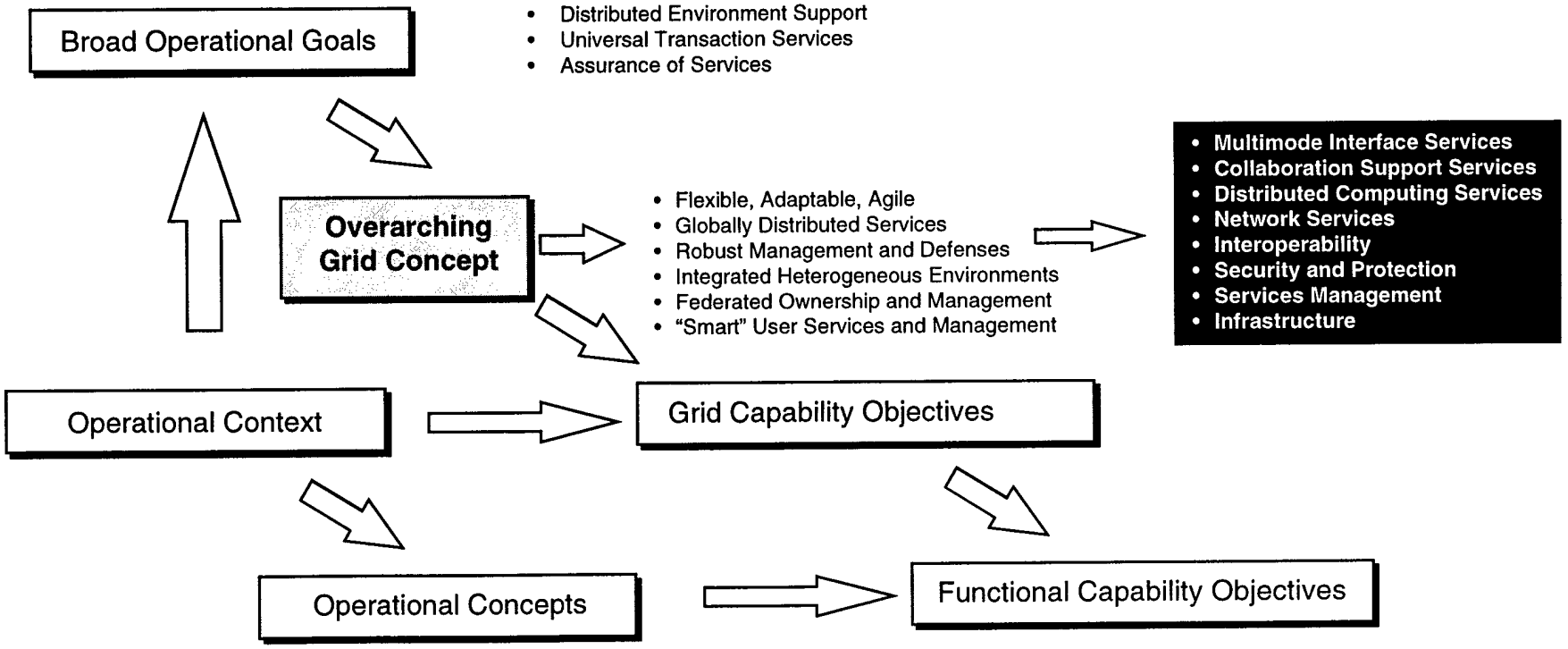
A "Federated Network" of Participating Systems and Users, With
a Mix of Individual Domains and Shared Assets



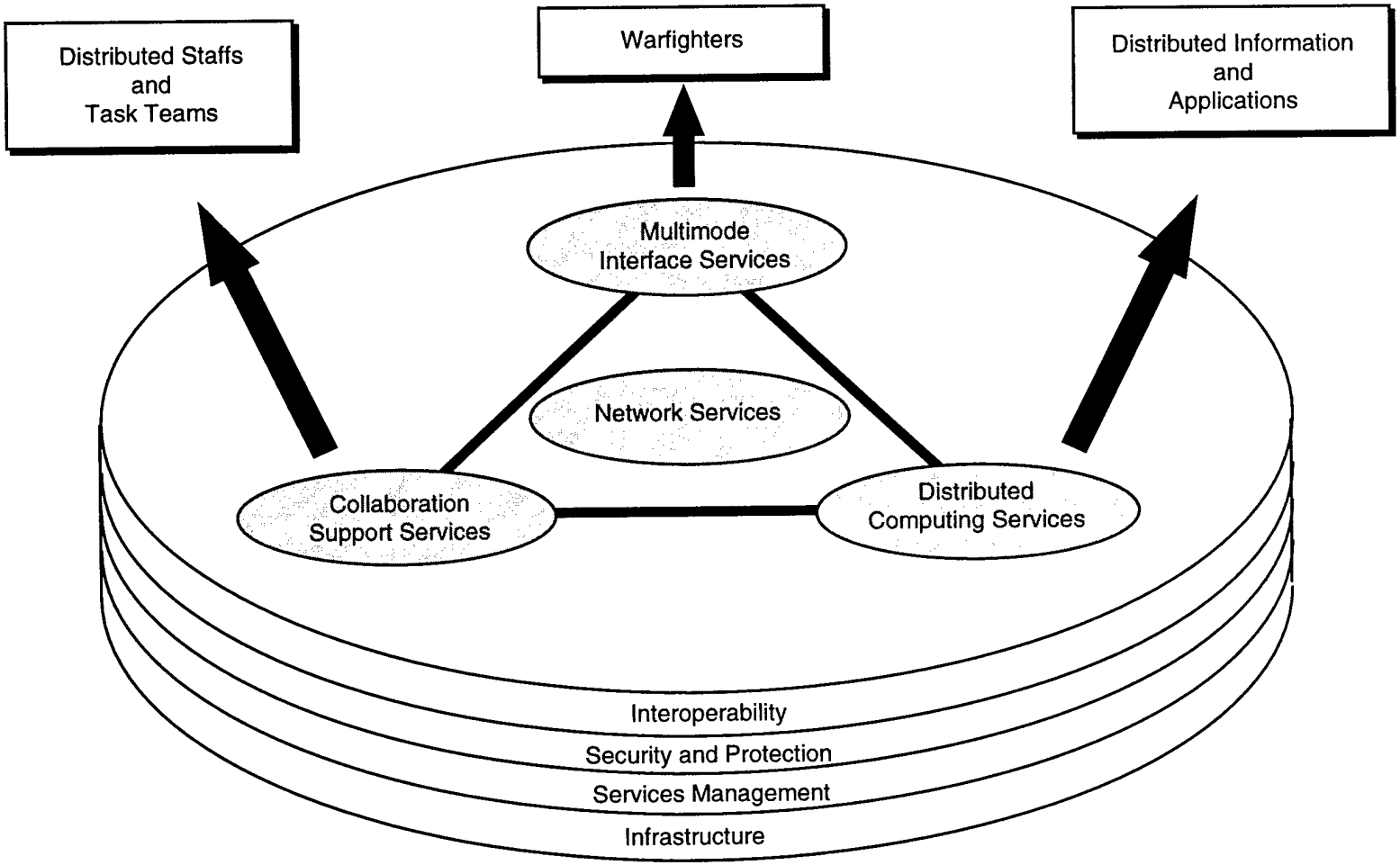
Ownership and Management Relationships in the Federated System



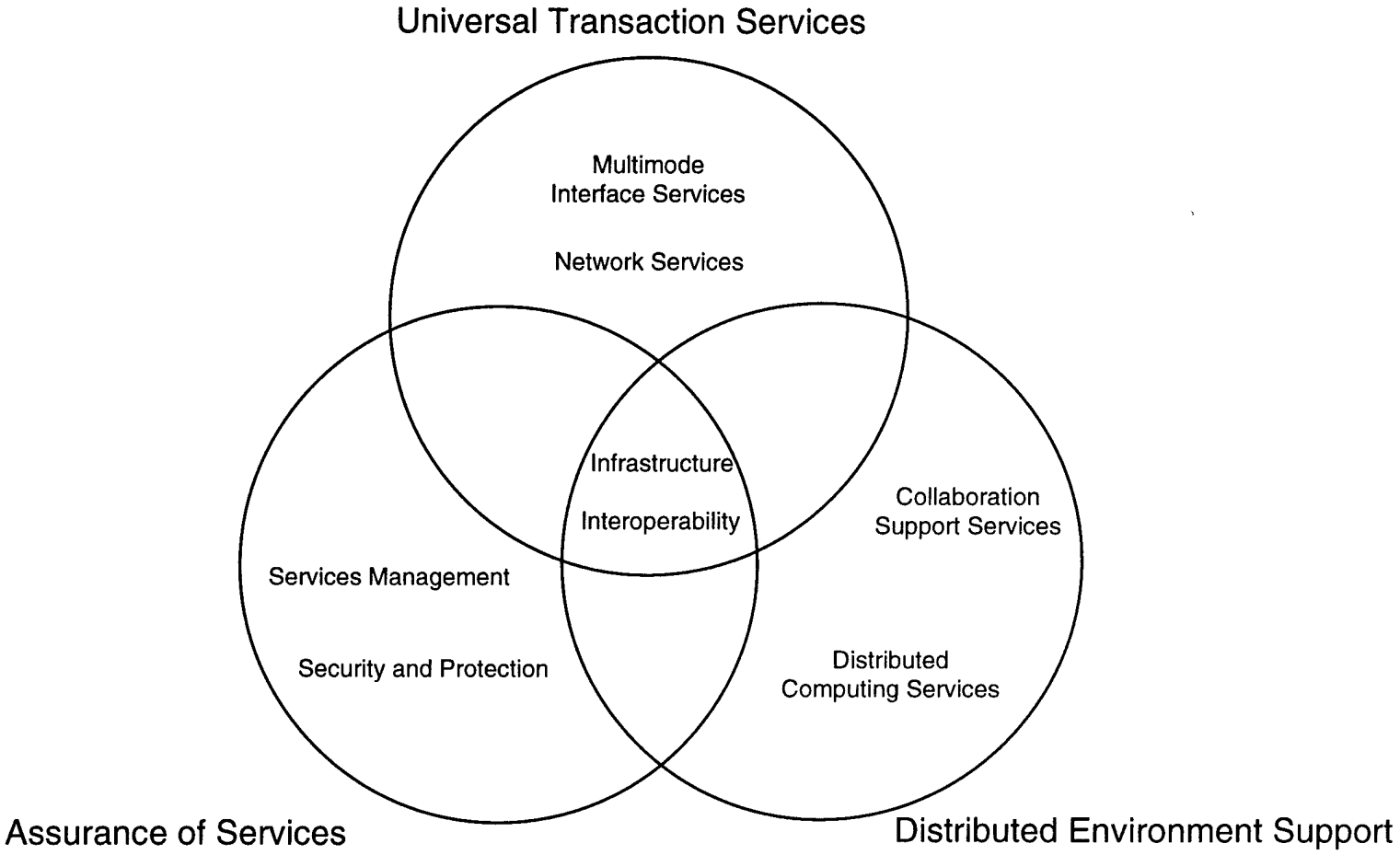
Developing the Capability Objectives



General Features of the Grid



Mapping of Grid Features Into the Principal Operational Capabilities

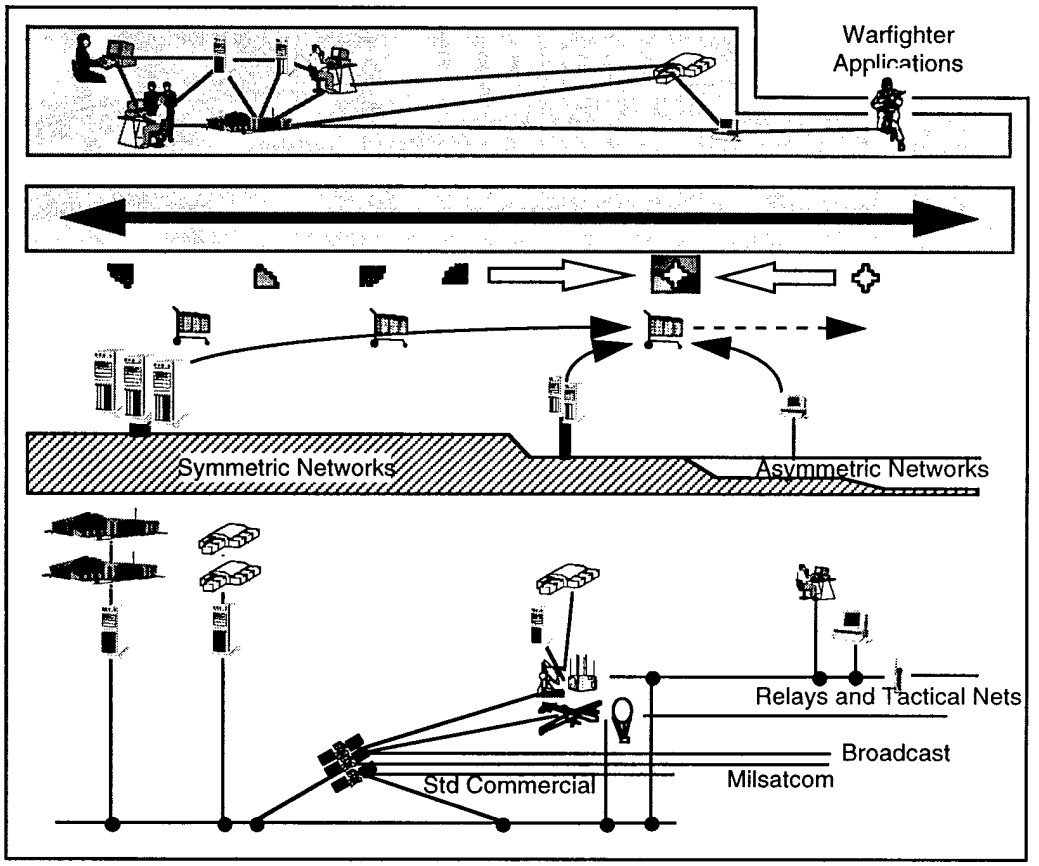


A Notional Grid

APPLICATIONS
- Distributed Virtual "Anchor Desk"
- Distributed "Warfighter's Associate"
- Collaboration Support (VTC, CVWs, etc.)

SERVICES
- Security and Protection
- Distributed System Management
- Heterogeneous System Services
- Intelligent Information Retrieval
- Information Repositories
- Multimedia Information Transport

INFRASTRUCTURE
- Software Support Centers
- System Management Centers
- Data Processing Centers
- Tactical Radio Networks
- Airborne Relay Networks
- Satellite Communications
- Terrestrial Communications (Fiber Plus Legacy Wire and Microwave)



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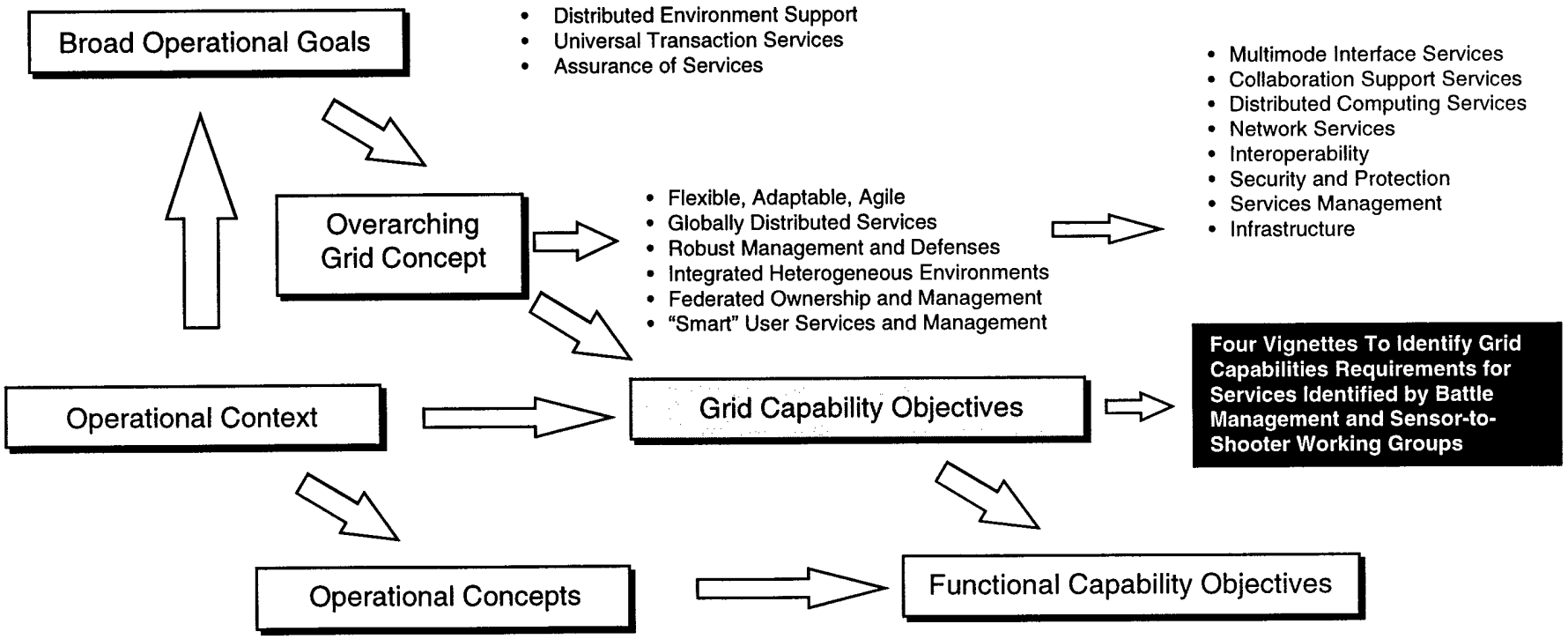
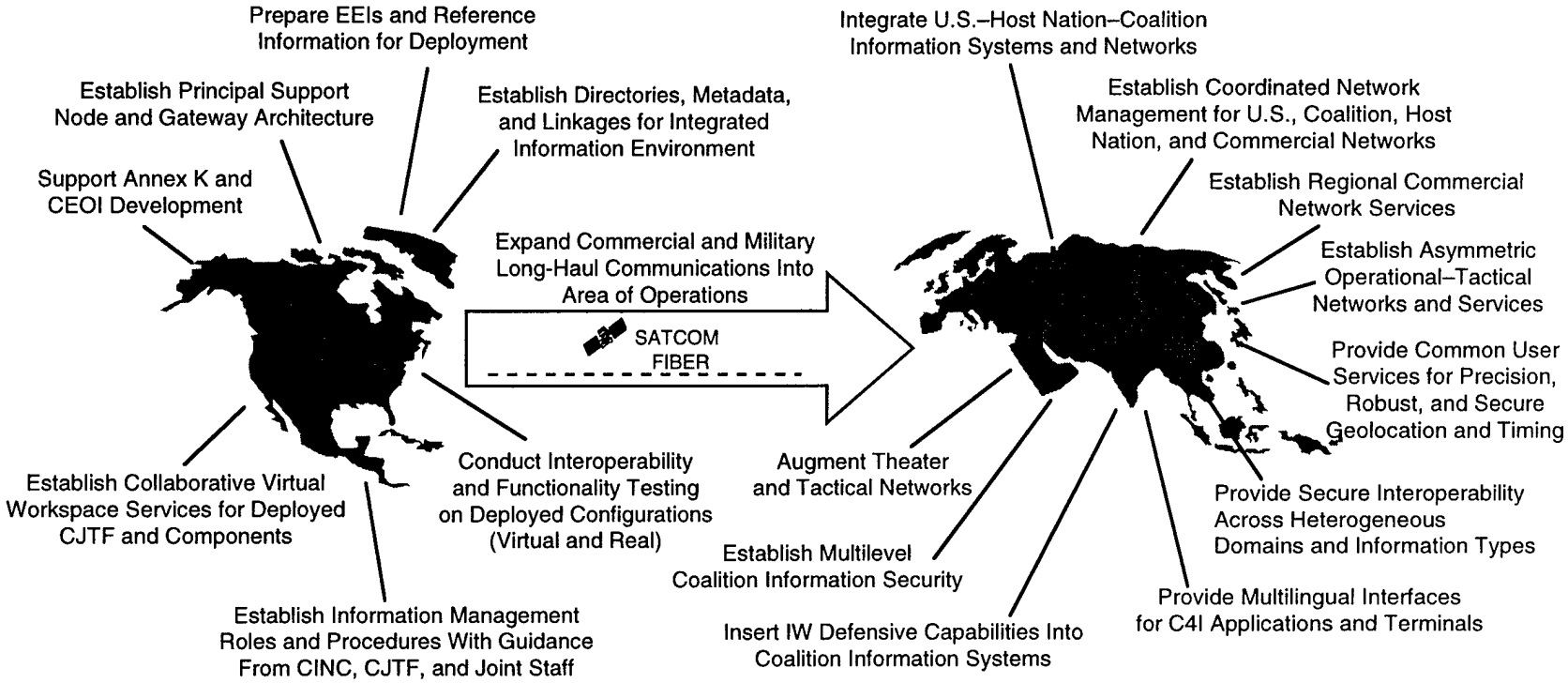


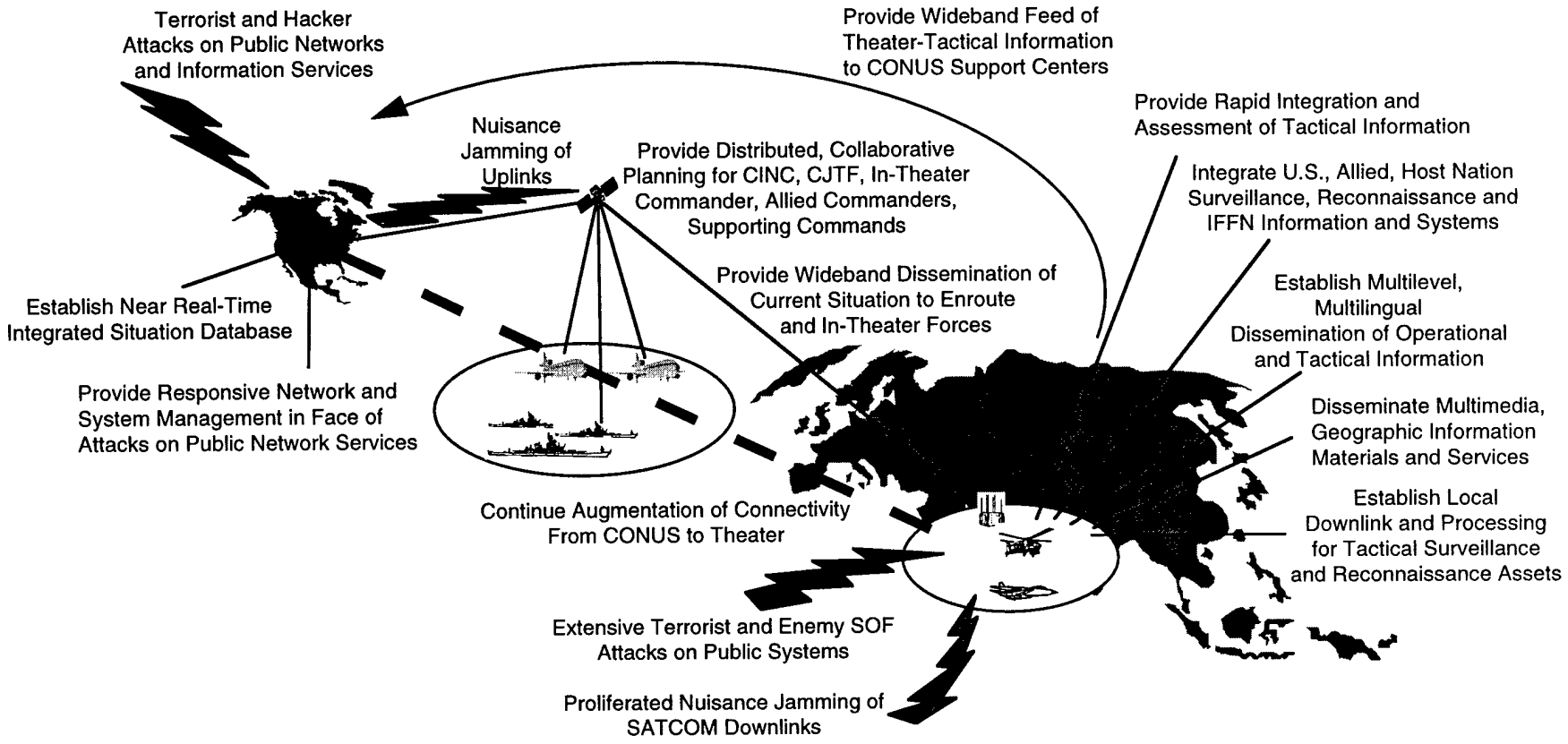
Vignette 1
Rapid Mobilization, Predeployment

Rapid Establishment of Infrastructure and Information To Support the Deployment
Time Scale: < 2 Days



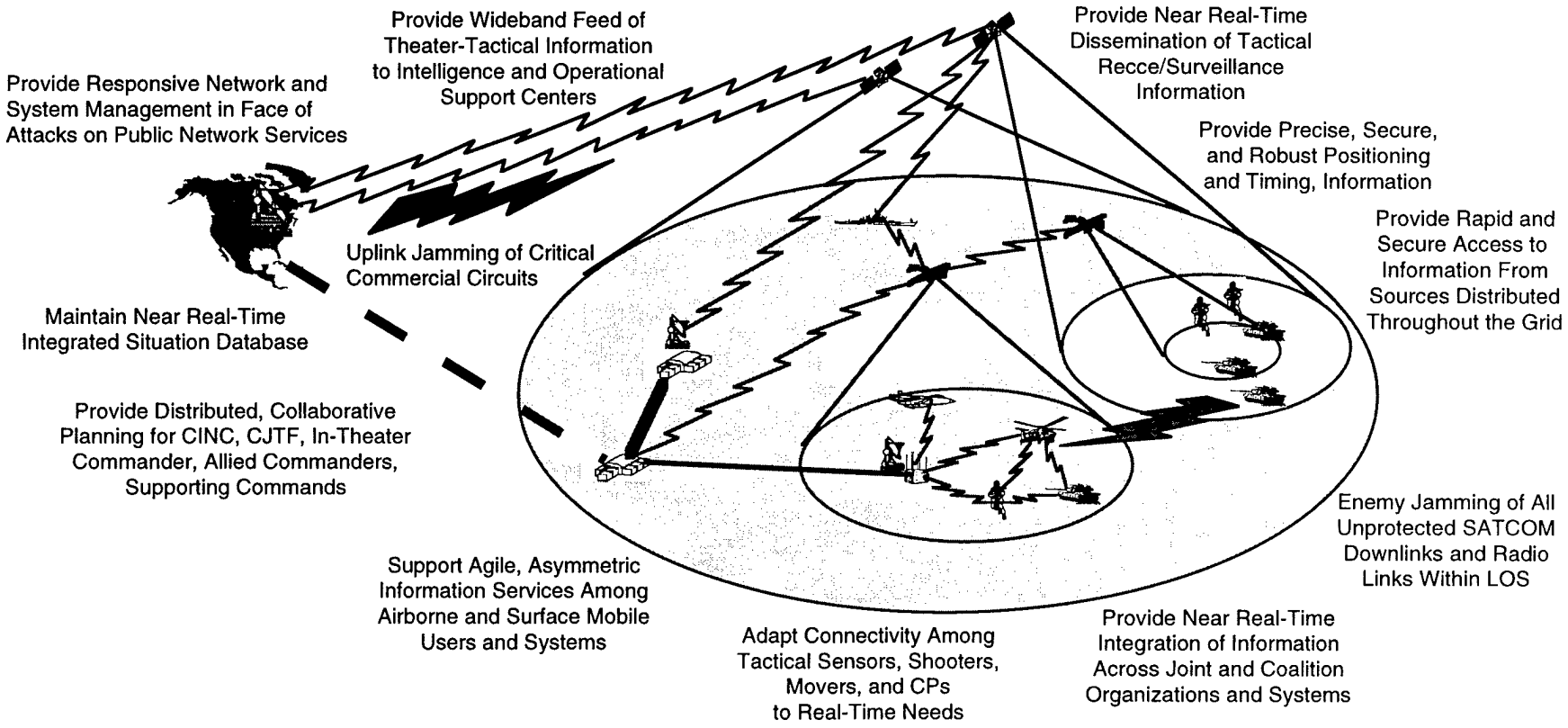
Vignette 2
Rapid Deployment, Entry, Reinforcement

Support IPB, Enroute Assessment and Planning, and In-Theater Coordination of Information, Plans, and Operations
Time Scale: Near Real-Time Information, Adaptation of Services Within 1 to 2 Hours



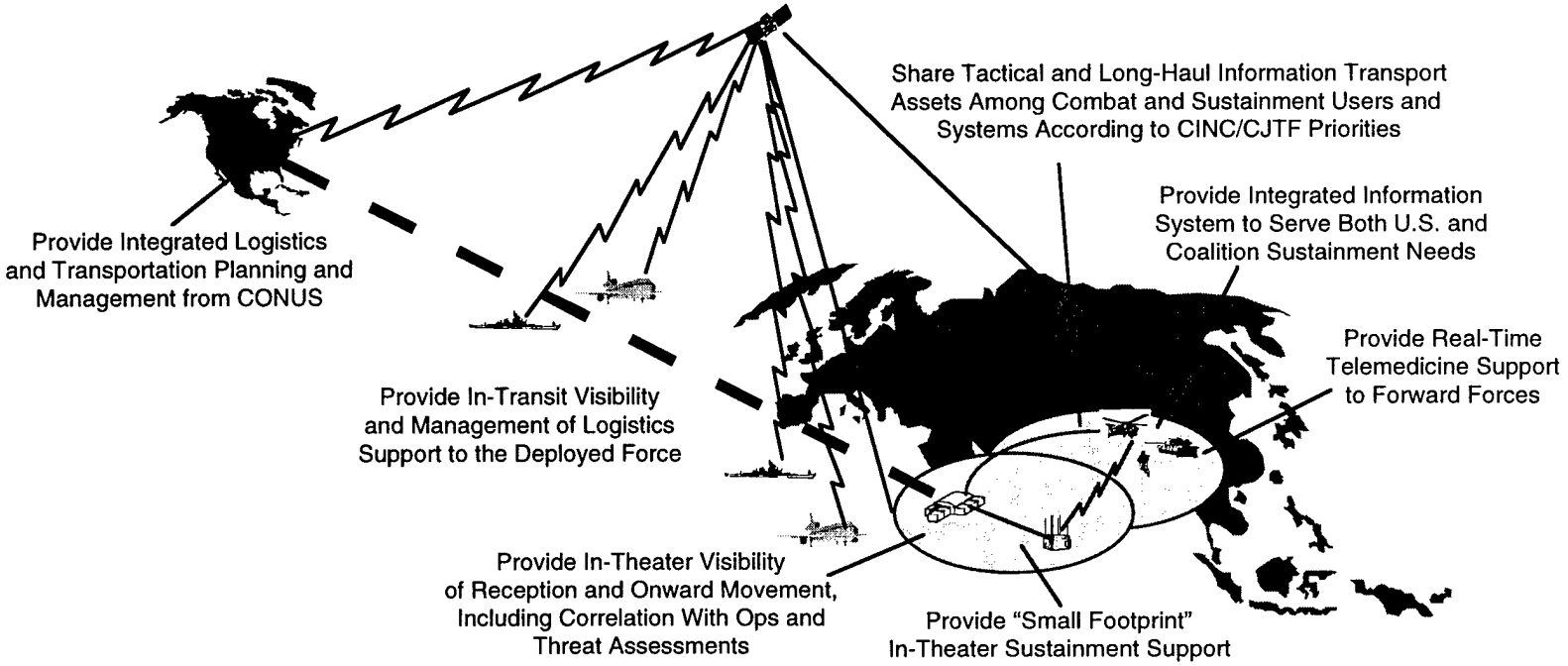
Vignette 3
Employment

Provide Seamless Information Dissemination and Collaborative Processes Involving Organizations and Resources in CONUS and Within the Theater, Including Interoperability With Coalition Forces and Civil Organizations
Time Scale: Near Real-Time Information; Adaptation of Services Within Minutes To Support Real-Time Operations



Vignette 4
Sustainment

Provide Connectivity and Information Management To Support Total Asset Visibility at Strategic and Operational Levels of Command
Support Distributed, Collaborative Logistics and Transportation Planning and Management
Support Asset Visibility and Sustainment Planning Among Operational and Tactical Commanders
Provide Telemedicine Support to Deployed Tactical Forces
Integrate Sustainment Support With Operational and Tactical System Resource Management According to CINC/CJTF Priorities
Time Scale: < 1 Hour for Tactical Logistics and Transportation Information, Real Time for Telemedicine



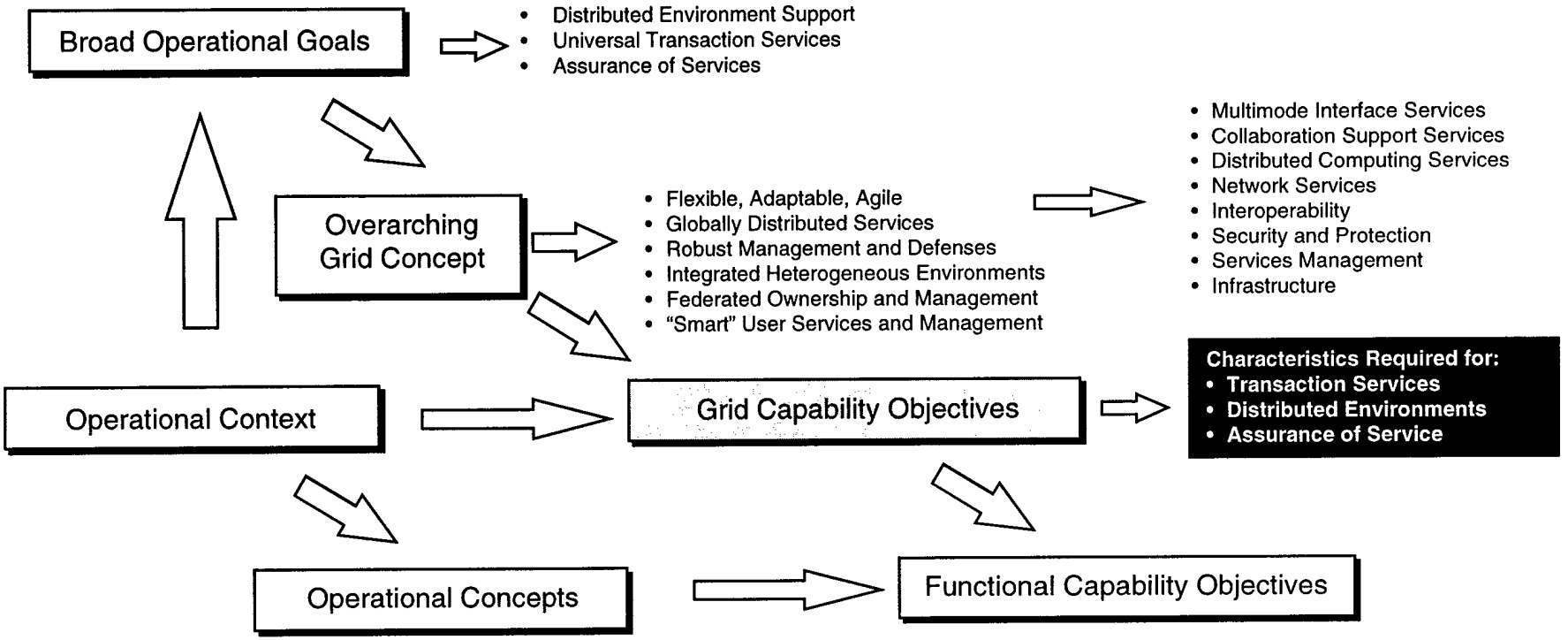
Battle Management Requirements for Grid Services

- Wideband Links to Users On-the-Move
- Rapid Dissemination of Common Operational Picture
- Broadcast Capability: Timely, Consistent, Concurrent Information
- Nonhierarchical Dissemination of Information
- Precise, Robust, and Secure Location and Timing Services
- Near Real-Time Dissemination of MC&G and Mensuration Information
- Distributed, Collaborative Environments, Including Multiechelon and Mobile
- Distributed, Heterogeneous Information System Services
- User Tailorable Interfaces and Visualization Services
- Collaborative, Virtual Workspaces
- Distributed Simulation Services
- Rapidly Tailorable Services
- Adaptive, Multilevel Security
- Scalability of Services
- Prepositioning of Information and Rapid Pull Capability

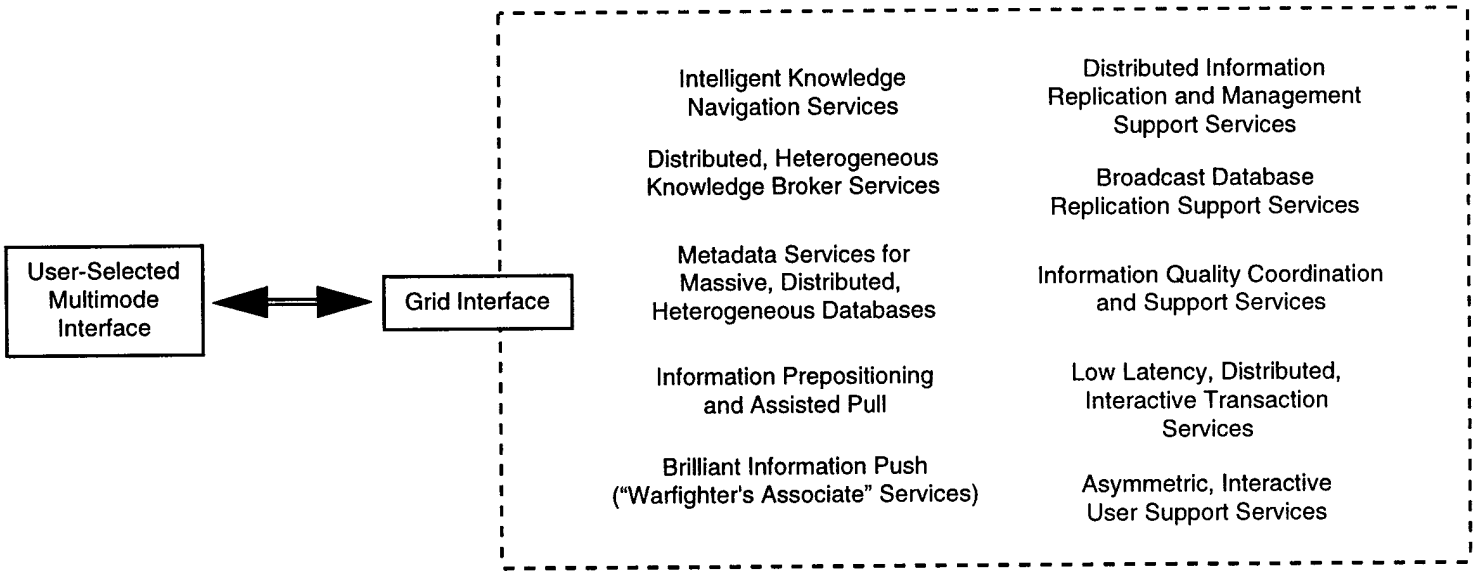
Sensor-to-Shooter Requirements for Grid Services

- Shared Situation Awareness to All Executing Elements of the Force
- Rapid, Continuous IPB and Joint Processing and Dissemination
- Support for Near Real-Time Joint Fusion
- Near Real-Time Execution Feedback for Ops Planning
- Real-Time Ability To Redirect Force Package Based on Changing Situation
- Integrated Processing Across Sensor-Shooter-CP Systems
- Real-Time Dissemination of Location and Identification of Targets, Threats, Friends, Neutrals
- Real-Time Delivery of Target Information Direct to Weapons and Platforms
- Integration of Nonconventional Sensors Into Sensor-Shooter Packages
- Real-Time Coordination Between Shooters and Tactical CPs
- Common, Consistent, Concurrent Operational Picture for All Users
- Tailored Common Picture for Different Individual User Needs
- Multilevel Security With Capability To Support Joint and Coalition Forces
- Assured, Adequate Connectivity to Mobile, Tactical Users

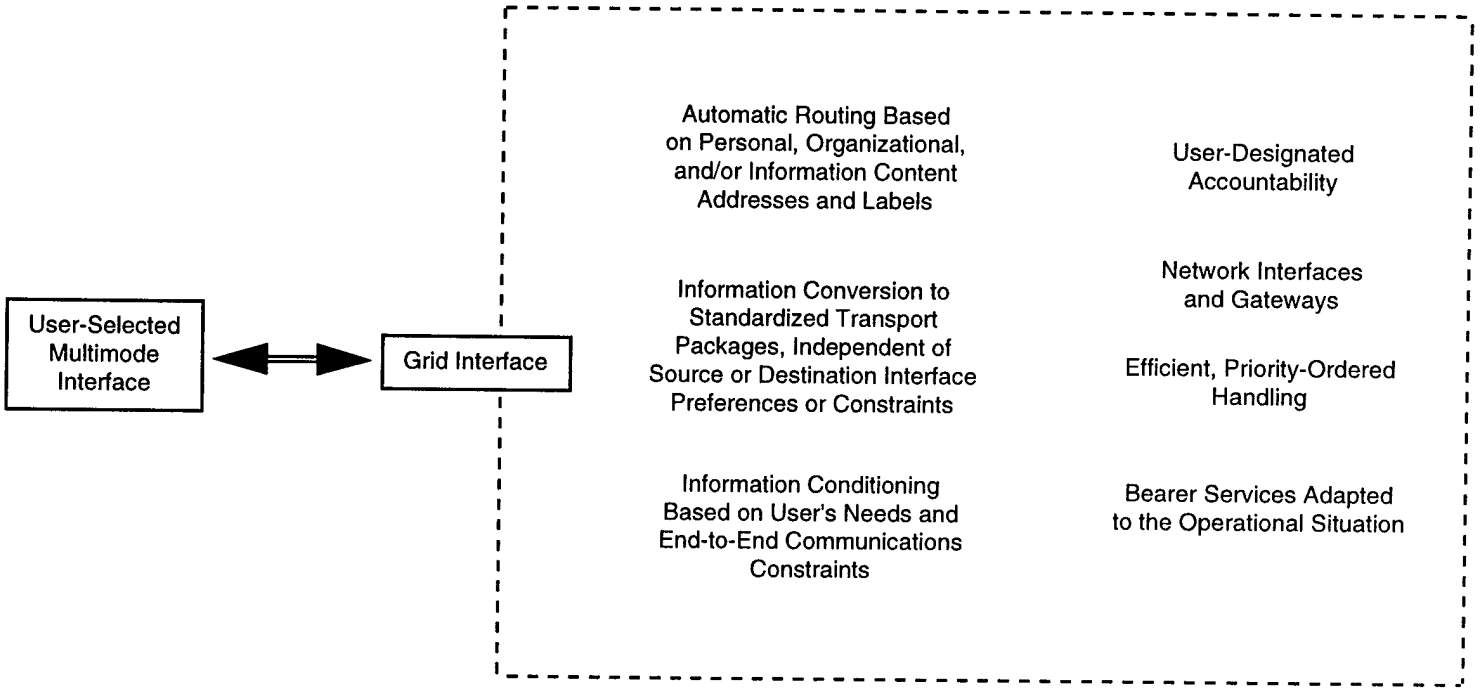
Developing the Capability Objectives



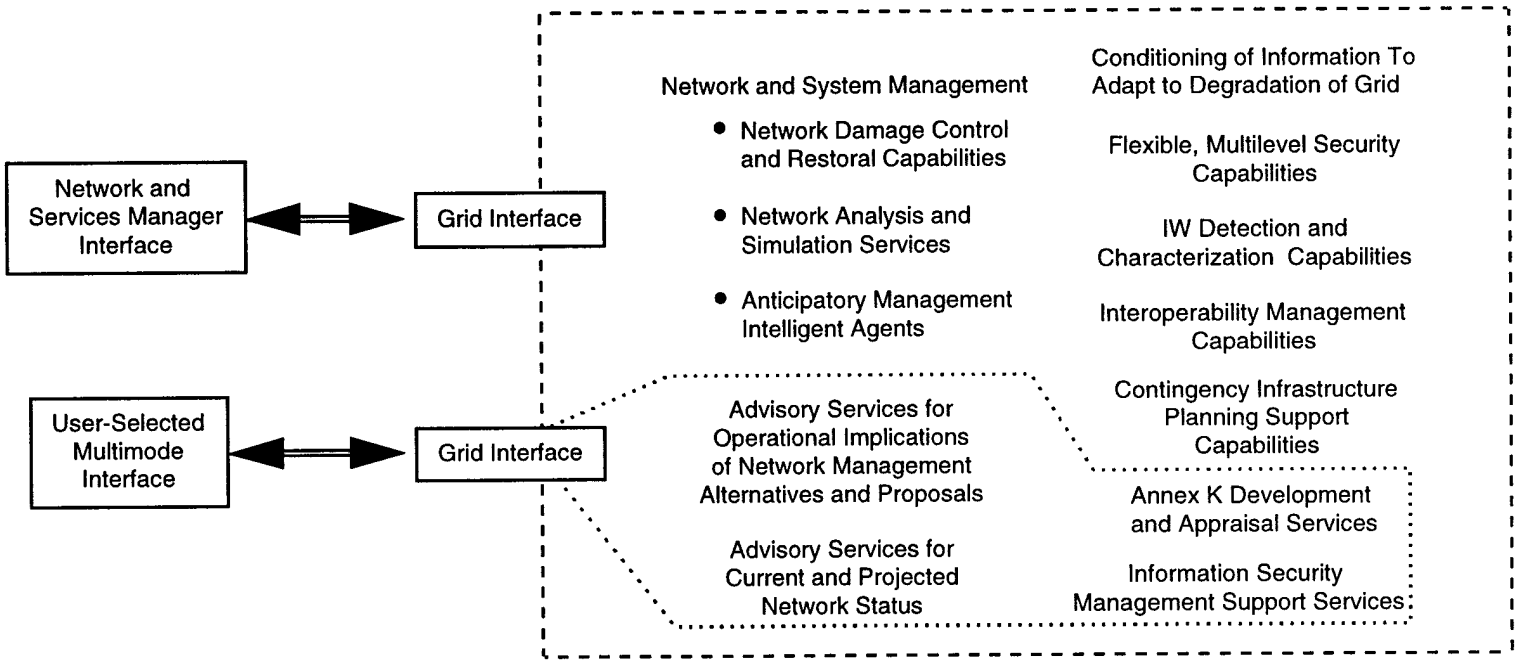
Required Characteristics for Distributed Environment Support



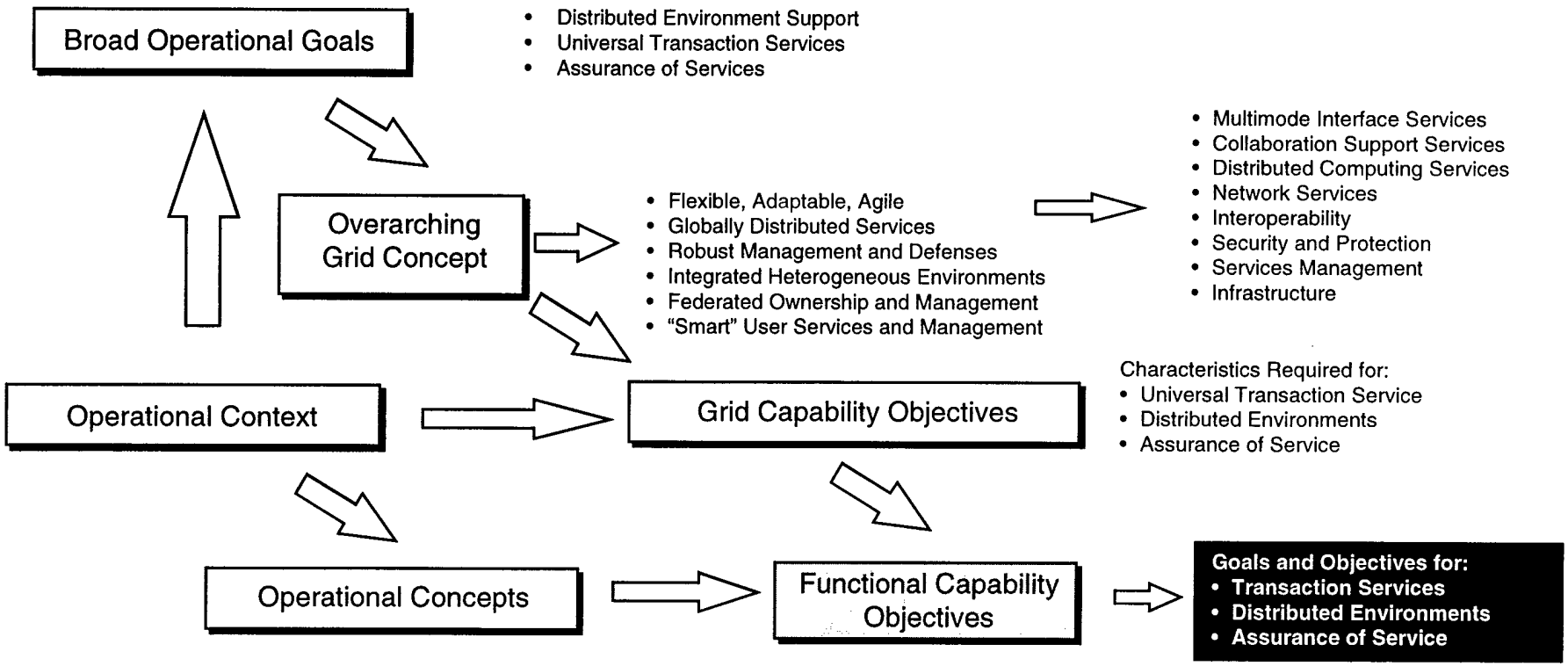
Required Characteristics for Universal Transaction Services



Required Characteristics for Assurance of Services



Developing the Capability Objectives



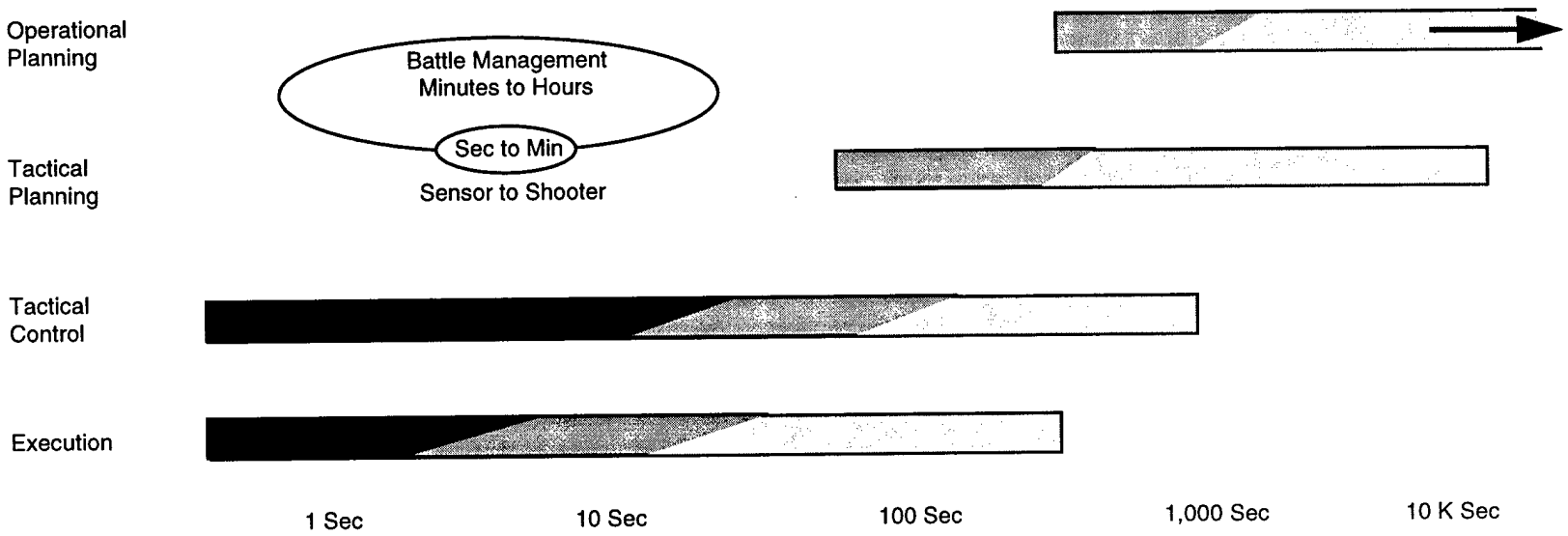
General Objectives for Distributed Environment Support

- Heterogeneous Information Broker and Mediator Services
  - — Contextual Interpretation To Span the Variety of Syntax and Context Models
  - — Translation and Conversion To Suit User's Interface and Perception Model
- Secure Interoperability for Dissemination and Integration of Distributed, Heterogeneous Information
- Knowledge Navigation and Retrieval Services
  - — Multidomain, Dynamic Metadata, and Cross-Referencing
  - — Intelligent Agents for Finding Information
- Knowledge-Based Awareness Services
  - — Distributed "Warfighter's Associate"
- Universal Geolocation and Timing Services
- Multidomain Information Consistency Management Services
  - — Automated Cross-Domain Correlation; Ambiguity and Conflict Resolution
  - — Multihypothesis Declaration, Tracking, and Alerting
- Interactive Session Support for Heterogeneous User Groups
  - — Virtual Workspace With Participants at All Levels of Capability (Video, Voice, Text)

Goals for Distributed Environment Support

- Smart Push or Pull of Planning Information Within Several Minutes
- Improved Quality and Timeliness of Decision Information Exploitation, Cross-Sensor Fusion, Flattening of Hierarchy
  - — 70 Percent Increase in Fusion Ability
  - — Dissemination of Critical Situation Changes in < 1 Minute
  - — 50 Percent Reduction in Time To Develop Forcewide Consistent Perception
- Disseminated Precision Position, ID, Status for Targets, Threats, Friendlies
  - — 136,000 Targets in MRC-W: 500 TCTs, 68,000 Enemy Movers, 800 Enemy Emitters
  - — Near Real-Time Updated Information: ~1-10 Sec for Fast Movers
  - — Unambiguous, Concurrent Dissemination Across Tactical AORs: 200 Nmi x 200 Nmi
- Distributed Collaborative Planning and Battle Management in Near Real Time
  - — Interactive, Collaborative, Virtual Workspace
  - — Distributed, Interactive Simulation, and C2 Planning Aids
  - — Heterogeneous Users: Varying Connectivities, Terminals, Interfaces
- Near Real-Time Distributed Information Access and Retrieval
  - — Focused Multidomain Database Search and Retrieval Within < 3 Minutes
  - — Total Grid Database Search and Retrieval Within < 30 Minutes
  - — Real-Time Mediation and Brokering for Distributed, Heterogeneous Environments

Interpretation of Timeliness Needs for Distributed Processes



Functional Definitions of Timeliness Regarding C2 Cycles

- Nonreal Time
- Near Real Time
- Real Time

General Objectives for Universal Transaction Services

- Common Protocols and Standards for Information Transport
  - — Transactions Based on Content, Not Source Data Formats or User Interface Modes
  - — Seamless From Strategic Backbone Through Tactical Radio Links
- Modular, Multilevel Encryption
  - — Model-Driven, Access Control at Information Element and Aggregate Levels
- Asymmetric Services To Meet Needs of Tactical Users
  - — Wideband Broadcast Dissemination up to Multimegabits Per Second
  - — Duplex Connectivity at Kilobits Per Second or Higher
- Adaptive Tactical Network Services
  - — Integration Across Terrestrial Links, SATCOM, Airborne Relays, Tactical Radios
  - — Logical Circuits Not Constrained to Physical Point-to-Point Links
  - — Ability To Connect Any User With Any Other User(s) Within a Few Seconds
- Adaptive Information Conditioning and Handling Services
  - — Automatic Compression and Coding To Respond to End-to-End Link Characteristics
  - — Automatic "Brokering" of Quantity Versus Timeliness To Suit Needs of Recipient
  - — End-User Characteristics Automatically Registered in Network
- Plain Language Addressing to Individuals, Organizations, and Groups
  - — Permanent Personal and Organizational Addresses

Goals for Universal Transaction Services

- Support Autoweaponeering and Combat Assessment of 500 Targets Per Hour
- Provide Target Material and BDA to Cockpit or Fire Support Team in < 1 Minute to Ground Team in < 3 Minutes
- Provide Direct Broadcast to Warfighter of 2,000 Target Updates Per Hour
- Support Autotarget-ID From IMINT/SIGINT at 400 Targets Per Hour
- Provide Tactical BDA in < 30 Seconds for Critical Targets; 2 Minutes for Priority Targets
- Bottom Line (Most Stressing) Capability Objectives:
  - Sensor-CP Delivery of High-Resolution Imagery To Support Planning: Through Wideband Backbone Circuits to Fixed Sites (for Imagery Analysis and Exploitation)
    - » Nominal 4K x 4K, 11 Bpp, 500 High-Resolution Images Per Hour
    - » Total Time From TOT to Delivery at CP: Less Than 30 Minutes
  - Sensor-Cockpit or Fire Support Team: Through Tactical Networks
    - » Nominal 1K x 1K, 8 Bpp Tactical Sensor or Overhead Imagery, 500 Actions Per Hour
    - » Total Time From Observation to Delivery at Cockpit or Fire Support Team: < 1–3 Minutes
  - BDA to CP and Shooters: Through Tactical Networks
    - » Nominal 1K x 1K, 8 Bpp Tactical Sensor or Overhead Imagery, ~ 400 Targets Per Hour
    - » Total Time From Observation to Delivery < 30 Seconds (Critical), 2 Minutes (Priority)

General Objectives for Assurance of Services

- Projection and Adaptation of Grid Infrastructure
  - — Modular Plug-and-Play of Communications and Computers To Match Force Packaging
  - — Augmentation of Fiber and SATCOM With Tactical Relays (UAV, Aerostat, Manned Aircraft)
  - — Global Projection of Services on Short Notice: Small Footprint in Forward Area
  - — Interoperability With Allied, Coalition, and Host Nation Users, Systems, and Services
  - — Automated Support for Annex K and CEOI Generation
  - — Predeployment Test and "Virtual" Operation
- Responsive, Dynamic Grid Management
  - — Anticipatory Network and Services Management
  - — Seamless Internetwork Management of Systems and Services, Including Defense and Restoral
  - — Collaborative Resource Sharing
- Defensive IW and Information Protection
  - — IW Sensing and C2 Capabilities as Adjuncts to Grid Management Systems
  - — Multilevel Security at the "Information Element" and Individual User Levels
  - — Protection Against Nuisance Threats
- Visualization Aids To Help Interpret Grid Capabilities in Operational Terms
  - — Linkage of Grid Status and Management Decision Alternatives to Operational Plans
- Integration of Information and Services Across the Grid
  - — Mediation of Heterogeneity
  - — Multilingual, Multimode Interfaces

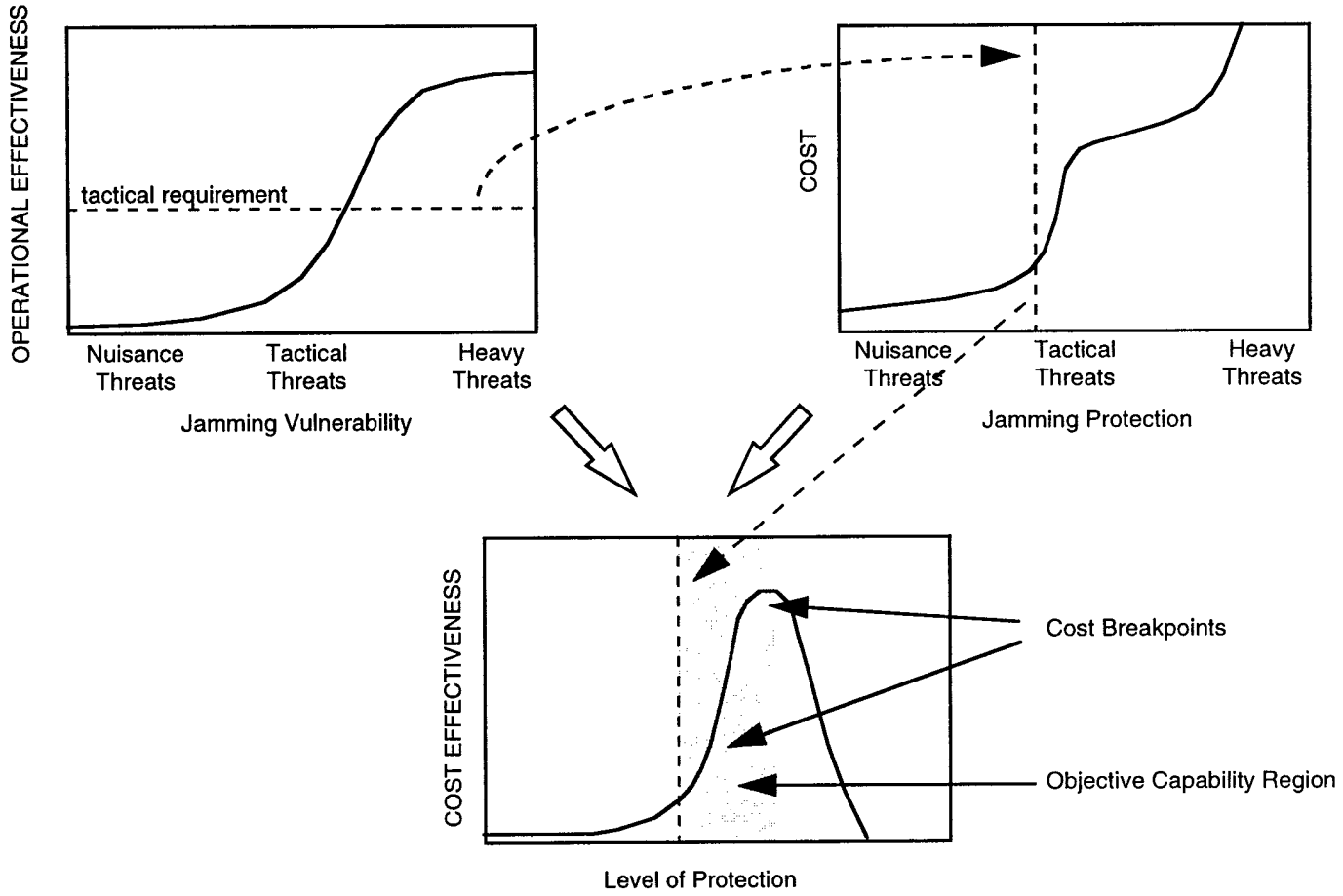
Goals for Assurance of Services

- Rapid Augmentation of Essential Grid Infrastructure and Services
  - — Integration and Augmentation of Airborne Relays Within 1 Hour
  - — Projection of Wideband SATCOM Circuits Into Theater Within 1 Day
  - — Projection of Fiber Into Theater and Tactical AOR Within 1 Week
- Adaptive, Multilevel Security With Over-the-Air Rekeying and Individual User/Information Element Access Control
  - — Cryptonet and INFOSEC Management Extended Throughout Coalition Force
  - — Automated Sanitization Gateways and Guards
- Anticipatory Services Management With Look-Ahead to at Least Two Operational Cycles
  - — CP Services Projected Out 1 Hour With 90 Percent Confidence, 3 Hours With 70 Percent, 1 Day With 50 Percent
  - — Tactical User/Platform/Sensor Services to 10 Minutes With 90 Percent, 1 Hour With 70 Percent, 3 Hours With 50 Percent
- Near Real-Time Management of Connectivities Through Backbone and Tactical Extension Networks
  - — Establishment of Operational Networks Within 10 Minutes
  - — Establishment of Tactical Action Team Networks Within 10 Seconds to 1 Minute

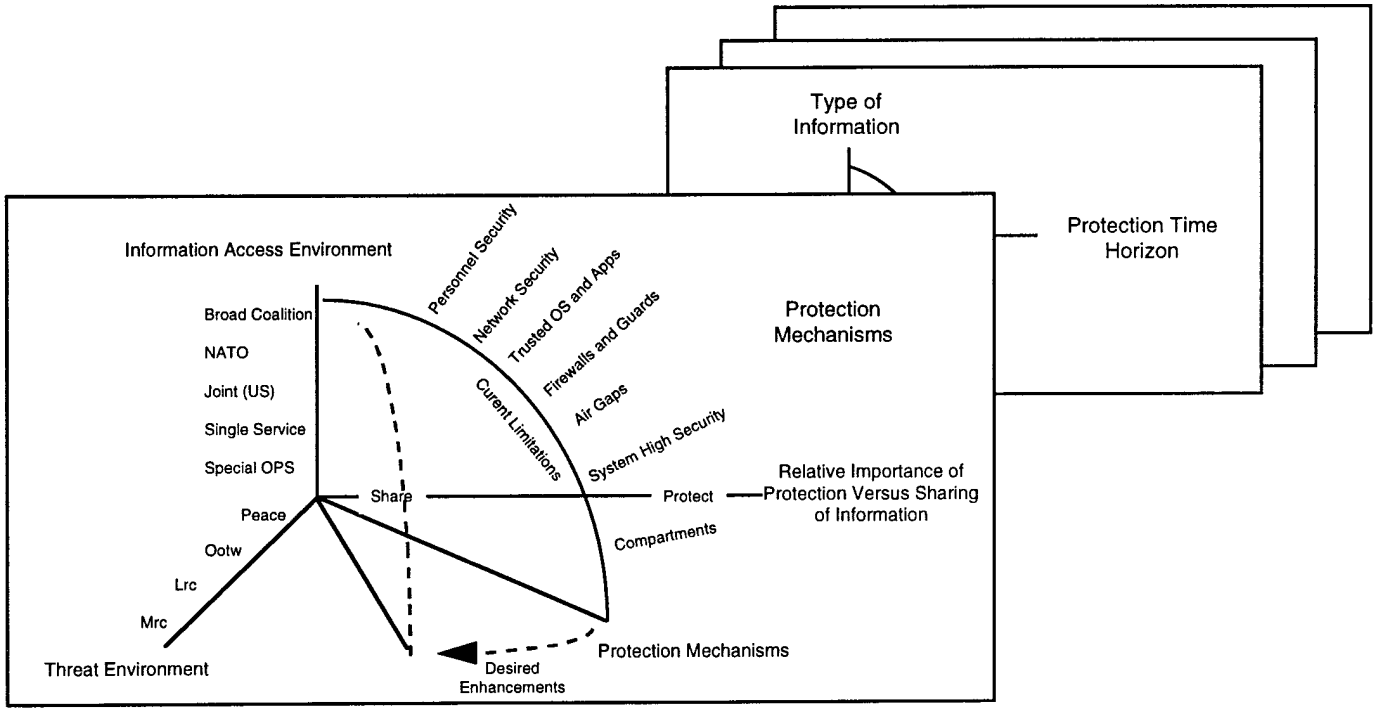
Goals for Assurance of Services *(Continued)*

- Near Real-Time Visualization of Operational Implications of Grid Status and Proposed Management Actions
  - — Simulated Impacts on Operations Presented to Network Managers Within 1 Minute for Tactical Network Management Decisions
  - — Simulated Impacts on Operations Presented to Network Managers Within 10 Minutes for Operational and Strategic Backbone Network Management Decisions
- Antijamming Protection for All Operational Circuits
  - — Total Protection Against Nuisance Threats: Disposable Jammers; < 10 Watts at 25 to 50 Miles
  - — Protection for Principal Circuits From Small Tactical Jammers: ~ 100–200 Watts at 50 Miles
- Protection of Critical Services From Unconventional Attacks
  - — EMP, Conductive Particle Clouds, Corrosive Agents, and the Like
- Real Time C4I for IW Defenses
  - — Detection, Correlation, and Characterization of IW Events Within 1 Second
  - — Localization of IW Attacks, Development of "Cybertracks," Threat Assessment Within 10 Seconds
  - — Coordination Across Grid Management Systems Within 30 Seconds
  - — Response to IW Attack Within 1 Minute
  - — Dissemination of IW Attack Advisories Within 1 Minute
  - — Damage Control and Restoral of Services and Information Within 3 Minutes

Objectives for IW Protection (Notional ECCM Example)



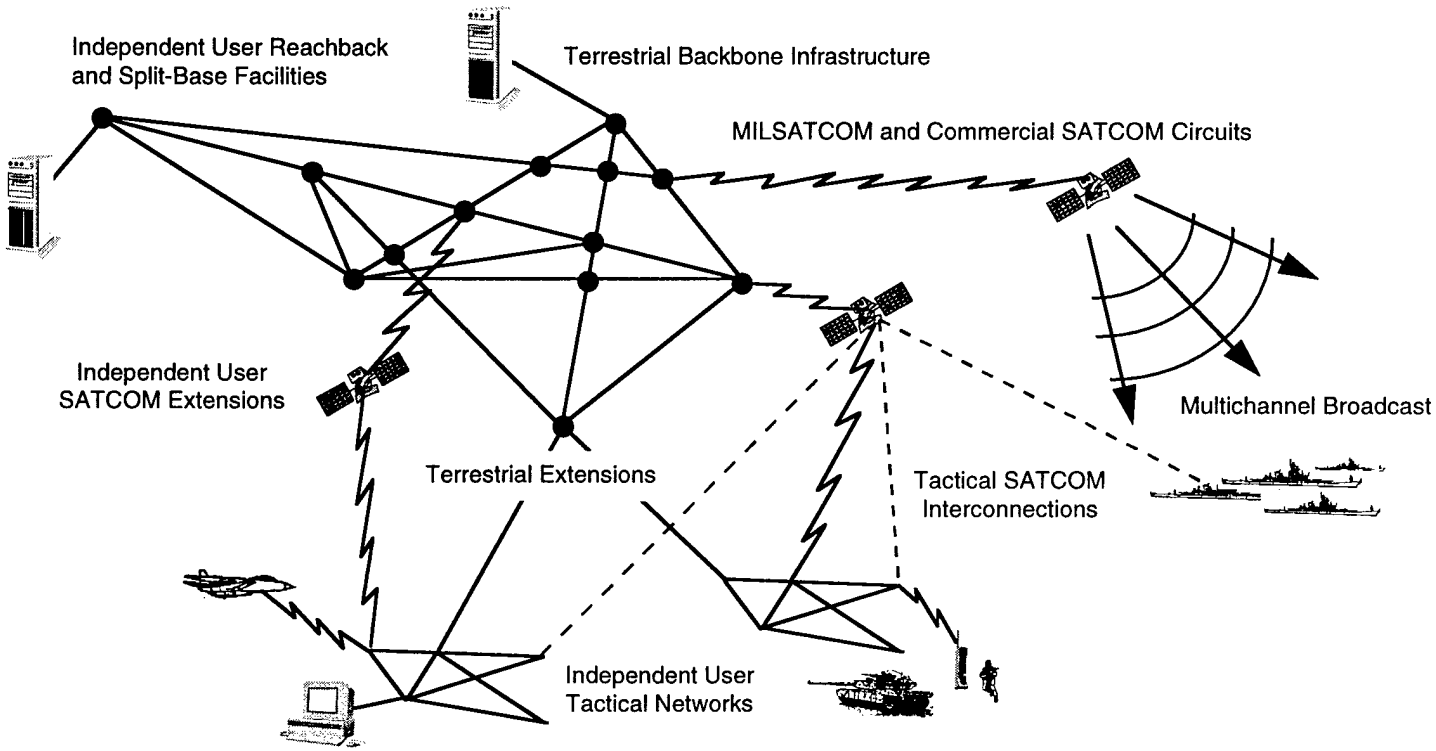
Objectives for IW Protection (Notional Information Security Example)



- Operational Context
- Broad Concepts
- Important Grid Capabilities
  - — Appraisal of Current Limitations
- Mapping of Current S&T Program
- Time Phasing of Operational Demonstrations and Technology Expectations
- Conclusions

Overview of the Current C4I "Grids"

Largely Connected Along Organizational Lines, With Some Improvements as Systems Evolve



Summary of Current Limitations: Distributed Environment Support

- Limited Ability To Integrate Processes Across Heterogeneous Systems
  - — Processes That Span the Strategic, Operational, and Tactical Domains, Including Coalitions
  - — Virtual Workspaces for Participants With Widely Varying Capabilities
- Inadequate Knowledge Navigation and Retrieval for Massive, Distributed, Heterogeneous Systems
  - — Lack of Metadata and Hyperlinks Across Distributed Information Repositories
  - — Lack of Intelligent Agents for Information Mining, Packaging, and Delivery
- Minimal Capability for Exploiting Information Within the Network to Provide Users With Knowledge and Advisory Cues
  - — Knowledge Availability Generally Limited to Organic or Own-Domain Sources
  - — IFFN and Status Based on Information Available Throughout the Grid in Various Forms
- Minimal Capability to Manage Distributed Information
  - — Consistency Across Domains
- Inadequate Real-Time, Precision Geographic Information Services
  - — Noncommonality in Geographic Referencing Systems and Services
  - — IW Vulnerabilities for Global Positioning and Timing: ECM and Enemy Use of Services
  - — Coverage Limitations With Current Precision Positioning and Timing Services
- Inadequate Information Security and Access Control
  - — Adaptive Services for Joint and Coalition Operations

Summary of Current Limitations: Universal Transaction Services

- Information Transport Generally Tied to C2 Hierarchy
  - — Inflexible, Organizationally Segmented
  - — Limited Ability To Establish Quick-Reaction Tactical Team Networks
- Limited Ability To Exchange Information Among Heterogeneous Users
  - — Multilingual, Multicultural
  - — Multimodal Interfaces
- Inability To Disseminate Information Simultaneously and Unambiguously to All Users
  - — Bandwidth and Connectivity Limitations
  - — Interoperability Limitations
- Unacceptable Limitations on Connectivity to and Among Tactical Users
- Lack of Adaptive Conditioning of Information to Optimize Services
  - — To Traverse "Narrow Pipes," Noisy Links, Degraded Links
  - — To Accommodate Users' Needs for Speed Versus Quantity of Information (High Resolution Imagery With Long Wait, Versus Low Resolution and Quick Delivery)
- Users Burdened With Requirement To Know Network Addresses
- Inadequate Information Security Capabilities (Adaptive, Multilevel Security for Joint and Coalition Operations)

Summary of Current Limitations: Assurance of Services

- Lack of Modular Plug-and-Play To Allow Adaptation of Services
  - — Networks and Systems Are Bundled With the Forces
  - — Multiple, Independent Tactical Information "Grids" in Same AOR
- Limited Ability To Project Information-Intensive Support Globally
  - — Independent "Reachback" and "Split Base" Information Processes and Systems
  - — Limited, Cumbersome, Constraining Gateways to Tactical Users
  - — Limited Automation To Help Match Resources to Plans
- Lack of Confidence That Nonorganic Assets Will Be There When Needed
  - — Fear of Preemption by Higher Authorities
  - — Desire for Control of Essential Capabilities
- Lack of Predictive/Anticipatory Network Management Capabilities
- Lack of IW Sensors and Processors for Grid Self Defense
- Limited Ability for Supporting Multilevel Security
  - — Information Security Versus Information Sharing
- Limited Ability To Provide Both Capability and "Hardness"
  - — Antijam and Protection From Unconventional Threats for Critical Services
  - — Robustness in Commercially Derived Systems and Services

- Operational Context
- Broad Concepts
- Important Grid Capabilities
  - — Summary of Enhancement Requirements
- Mapping of Current S&T Program
- Time Phasing of Operational Demonstrations and Technology Expectations
- Conclusions

Enhancements Needed To Support Battle Management

Distributed Environment Support

Intelligent Agents for Distributed, Heterogeneous Database Search and Retrieval

Rapid Dissemination of Consistent, Common Picture

Common Geolocation and Timing

Cross-Domain Normalization and Fusion Services

Interoperability Across User Applications and Systems

Prepositioning of Important Information

Shared War Plan Objects

Distributed Virtual Staff Support Services

Distributed Simulation Support Services

Universal Transaction Services

End-to-End Interoperability Across Heterogeneous User Domains

Wideband Links to Users On-the-Move

Broadcast Information Dissemination Direct to Warfighters

Wideband, Low Latency Comms for Interactive Processes

End-User Tailoring of Interface and Presentation

Responsive, Wideband Communications for Sensor Cross-Cueing

Assurance of Services

Rapid, Dynamic Bandwidth Allocation

Adaptable, Globally Projectable Wideband Comms Infrastructure

Predictive Adaptation of Services

Coordinated Management of Grid and User Networks

IW and Physical Protection Matched to Operational Needs

Adaptable Multilevel INFOSEC

IW Integrated With Operations

Enhancements Needed To Support Sensor-to-Shooter

Distributed Environment Support

Formatting and Registration of Information From Distributed, Heterogeneous Sources

Rapid Push of Target Information from Multiple, Heterogeneous Sources

Near Real-Time Integration and Dissemination of Information From Multiple, Heterogeneous Sources

Seamless Integration of Tactical and Nontactical Information

Rapid Multisource Combat Identification Service

Precision Positioning and Timing Information

Universal Transaction Services

Rapid Establishment of Wideband Links Among Moving Sensors and Shooters

Rapid Establishment of Multiple Sensor-Shooter Team Network Services

"Flattened" Movement of Information From Sources to Shooters and Command Centers

End-to-End Interoperability Across Heterogeneous User Domains

Wideband, Low Latency Dissemination of Imagery and Intelligence Information

Immediate, Cooperative IFF Information

Responsive, Wideband Communications for Sensor Cross-Cueing

Assurance of Services

Rapid, Dynamic Bandwidth Allocation

Predictive Adaptation of Services

Coordinated Management of Grid and User Networks

Agile, Adaptive, Multilevel INFOSEC

IW Integrated With Operations

Projection of Services Into Hostile Environment

Projection of Warfighting Networks in AOR Before Initial Entry

Important Functional Capability Enhancement Needs

Distributed Environment Support

Sessions With Heterogeneous Users and Modes

Distributed Processes: Workspaces, Simulations

Knowledge Navigation and Retrieval

Total Grid Knowledge Exploitation

Common, Consistent, Robust Geolocation and Timing Services

Massive, Distributed, Heterogeneous Information management

Information Security for Distributed Heterogeneous Systems

Universal Transaction Services

Flexible, Nonhierarchical Transport

Exchanges Among Heterogeneous Modes and Users

Consistent, Concurrent Dissemination

Connectivity to and Among Tactical Users

Adaptive Conditioning of Information

Automatic, Adaptive Addressing

Flexible, Adaptive Access Control: Information Security, Privileges

Assurance of Services

Modular Plug-and-Play

Project Information-Intensive Support Globally

Visualization of Grid Ability to Support Operations

Responsive Network and System Management

Grid Self Defense

Multilevel Security

Capability and "Hardness" in Critical Services

- Operational Context
- Broad Concepts
- Important Grid Capabilities
- Mapping of Current S&T Program
  - — Technology Challenges
- Time Phasing of Operational Demonstrations and Technology Expectations
- Conclusions

Distributed Environment Support

- Knowledge Search, Discovery, Retrieval, and Exploitation for Massive, Distributed, Heterogeneous Information Systems
  - "Knowbots" and Other Intelligent Agents: Beyond Text Oriented Search Tools
  - Distributed Warfighter's Associate Agents for Information Mining and Integration
  - Smart Triggers and Hyperlinks for Knowledge Assembly and Presentation

- Multilevel, Adaptive Information Security: With Coalition Capabilities
  - MLS at the Information Element Level and Individual User Level
  - Location-Independent User Access Authentication
  - Rapid (< 1 Minute) Reconfiguration of Access; Rekeying Across Grid

- Distributed Collaborative Processes Among Heterogeneous Users
  - Heterogeneous Multimedia Conferencing
  - Multilingual, Multicultural Interfaces
  - Contextual Integration and Interpretation of Information
  - Rapid Adaptation of Knowledge Mediators and Brokers to Changing Heterogeneity

Universal Transaction Services

- Automatic Brokering of Transaction Parameters Across Network
  - — Custom Tailored Conditioning and Compression at Gateways
  - — End User Selection of Form, Content, and Speed of Service
- Multilevel, Adaptive Information Security: With Coalition Capabilities
  - — MLS at the Information Element Level and Individual User Level
  - — Location-Independent User Access Authentication
  - — Rapid (< 1 Minute) Reconfiguration of Access; Rekeying Across Grid
- Mechanisms for Universal Information-Oriented Transactions
  - — Protocols, Standards, and the Like
- Robust Networking for Tactical/Mobile Users
  - — Automatic, Smart Adaptation of Transport to Provide Priority-Ordered Service for Dynamic User Requirements and Priorities and Fluid Battlespace Network Topologies
- Integrated Asymmetric Networks and Services
  - — From Wideband Circuits (> 1 Mb/s) Through Tactical Radio Links (< 64 Kb/s)
- Tactically Extensible Fiberoptic Communications

Assurance of Services

- IW Surveillance and Defense Tools
  - — Protection and Response Measures for Hacker and Terrorist Threats Against Commercial Infrastructure and Services
  - — Near Real-Time, Gridwide Detection, Characterization, and Response to IW Attacks
- Anticipatory Services Management Tools
  - — Look-Ahead Capability Out to Several "Cycle Times" for Battle Management and Sensor-to-Shooter Cycles
- Integrated, Multidomain System Management With Visualization of and Projection of Operational Implications Tools
  - — Full Visibility of Management Decision Alternatives on All Elements of the Grid, From Strategic and Operational Levels Through Tactical Systems
  - — Full Near Real-Time Visualization of Current and Projected Status of Grid, Across All Domains
- Antijam Defense Against Nuisance Jammers for Operational Networks Derived From Commercial Sources
  - — SATCOM Downlink Jamming From Disposable (<10 Watt) Jammers
  - — SATCOM Uplink Jamming From CONUS-Based, Distributed Jammer Networks (>100 W/Jammer)
- Multilevel, Adaptive Information Security

Overview of Critical S&T Needs

- Universal Information Transaction Mechanisms: Standards, Protocols
- Language, Syntax, Protocol Translation
- Self-Adapting Tactical/Mobile Networking
- Rapidly Deployable Fiberoptic Communications
- High-Rate and Asymmetric Mobile Communications
- Automated Adaptive Information Compression, Coding, Abstracting
- Automated Mediators and Database Management Tools
- Massive Data Storage and Management
- Intelligent Knowledge Discovery, Retrieval, and Integration Agents
- Robust, Secure, Precise Geolocation and Timing Available in All Environments
- Multimode, Multilingual Interface Services
- Heterogeneous Multimedia Conferencing
- Anticipatory Services Management Tools
- Visualization Tools for Status and Projected Capability
- Advanced Adaptive Information Security at the Data Element, Aggregate, and Individual User Levels
- IW Surveillance and Defense Capabilities

Mapping of Functional Enhancements to Critical Enabling Technologies

FUNCTIONAL CAPABILITIES	Universal Transaction Mechanisms	Language, Syntax, Protocol Translation	Self-Adapting Tactical/Mobile Networking	Rapidly Deployable Fiber	High Rate and Asymmetric Mobile Comms	High-Rate Broadcast	Robust Geolocation	Compression, Coding, Abstracting	Automated Mediators and DBMS Tools	Massive Data Storage and Management	Info Discovery, Retrieval, Integration	Multimode, Multilingual Interface	Heterogeneous Multimedia Conferencing	Anticipatory Services Management	Visualization Tools	Robust Appliques for Commercial Systems	Advanced, Adaptive INFOSEC	IW Surveillance and Defense
Transaction Services:																		
Flexible, Nonhierarchical Transport	●	●	●		●	●		●									●	
Exchanges Among Heterogeneous Modes and Users	●	●						●	●								●	
Consistent, Concurrent Dissemination	●	●	●		●	●											●	
Connectivity to and Among Tactical Users	●	●			●	●		●									●	
Adaptive Conditioning of Information								●									●	
Automatic, Adaptive Addressing	●	●	●															
Flexible, Adaptive Access Control: INFOSEC, Privileges																	●	
Distributed Environment Services:																		
Sessions With Heterogeneous Users and Modes	●	●							●			●	●				●	
Distributed Processes: Workspaces, Simulations	●											●	●				●	
Knowledge Navigation and Retrieval		●							●		●				●		●	
Total Grid Knowledge Exploitation		●							●		●	●			●			
Common, Consistent, Robust Geolocation and Timing							●											
Massive, Distributed, Heterogeneous Information Management						●			●	●								
INFOSEC for Distributed Heterogeneous Systems																	●	
Assurance of Services:																		
Modular Plug-and-Play	●	●	●						●			●						
Project Information-Intensive Support Globally	●	●	●	●	●			●										
Visualization of Grid Ability to Support Operations														●	●			
Responsive Network and System Management														●	●			
Grid Self-Defense															●		●	●
Multilevel Security																	●	
Capability and Hardness in Critical Services														●		●		●

- Operational Context
- Broad Concepts
- Important Grid Capabilities
- Mapping of Current S&T Program
  - Impacts of Current and Planned Technology Efforts
- Time Phasing of Operational Demonstrations and Technology Expectations
- Conclusions

Overview of Important Ongoing Enhancement Activities

- Wideband and Asymmetric Communications
  - — Significant, Well Directed Wideband Development (Fiber, SATCOM, Relays)
  - — Requires Additional Effort To Integrate With Operational Networks
- Networking
  - — Emphasis on Tactical "Domain-Oriented" Networks and Strategic Backbone (e.g., IP, DMS)
  - — Requires Additional Effort for Robust, Joint/Combined Tactical Networks
- System Management
  - — Emphasis on Integration Across Domain Management Systems (e.g., JCPMS)
  - — Minimal Effort Toward Anticipatory Management
  - — Minimal Development of Tools To Support Visualization of Operational Implications
- Heterogeneity Management
  - — Emphasis on Mediators for Standard Database Systems (e.g., Oracle, Sybase, Informix)
- Information Security
  - — Emphasis on Key Agile, Wideband, and Cell Encryption (e.g., OTAR, Firefly, Fastlane)
  - — Rudimentary MLS Devices (e.g., Firewalls, Radiant Mercury, CMW/OIW)
  - — Flexible, Adaptable MLS Remains Beyond Reach
- Information Conditioning
  - — Emphasis on Source-Directed Conditioning (Progressive JPEG, Radiant Tin, etc.)
  - — Requires Integration of Conditioning, Transport, and Transaction Processing Systems

Important Technical Enhancements Addressed in Current S&T Program

Distributed Environment Support

1995 TAP Objectives Through 2005	Contribution to Grid Capability Objectives	Remaining Critical Needs
• Distributed Computing Environment Support – Demonstration on ATM Backbone – Adaptive Distribution Over Tactical Links – Adaptive Dissemination Based on Content	• Heterogeneity Management Services	• Distributed Warfighter's Associate – Ability To Execute "Brilliant Push" From a Massive, Distributed, Heterogeneous Environment – Automated Interaction of Intelligent Applications at the User Terminal and Distributed Throughout the Grid
• Hybrid, Real-Time/Non-Real-Time, Heterogeneous Global Information System	• Knowledge Navigation and Retrieval Services, With Some Capability for Contextual and Knowledge-Based Retrieval in Massive, Heterogeneous Environments	• Intelligent Metadata and Linking Services To Provide Very Rapid and Precise Location and Retrieval of Information From Massive, Distributed, Heterogeneous Environment
• Knowledge Query, Manipulation, and Mediation in a Heterogeneous Environment	• Intelligent Agents To Support "Assisted" Pull From Distributed, Heterogeneous Information Sources	• Intelligent Applications for Integration of Knowledge, Assumptions, and Unknowns Across Massive, Heterogeneous, Inconsistent Information Sources
• Intelligent Agents for Information Location and Integration Based on "Fuzzy" Queries	• Smart Alarms and Smart Triggers, With Some Capability to Deal With Massive, Distributed, Heterogeneous Information Environments	• Interactive Session Support for Distributed, Collaborative, Virtual Workspaces With Users of Varying Transaction Capabilities
• Interoperability of Joint Forces Using Common Information Management and Distribution With Capability To Access, Share, and Protect Critical Information	• Information Conditioning at Source To Match Network Transactions to End-User Needs and Constraints	
• Automated Situation Reasoning: Multimedia Compression for Sensor/Shooter Targeting, Combat ID, Multihypothesis Data Fusion	• Fully Interactive Collaborative Workspace Support With Some Accommodation of Variations in Participant Capabilities and Connectivities	
• Fully Interactive, Multisite, Collaborative Planning, Replanning Across Missions, Echelons, and Services	• Responsive Establishment of Distributed User Networks for Selected Planning, Tasking, and Control Processes	
• Near Real-Time Dissemination and Coordination of Planning and Tasking Information, Including Enroute C2 and Direct Sensor/Shooter Tasking		

Important Technical Enhancements Addressed in Current S&T Program

Universal Transaction Services

1995 TAP Objectives Through 2005	Contribution to Grid Capability Objectives	Remaining Critical Needs
• Demonstrate Integrated Voice and Data on 2.4 Kbps Ckts (Data/Voice Integration ATD, etc.) • Commercial Standards and Protocols for Most DoD Communications (e.g., DBC ATD) • Extend Global Grid (ATM) to All Warfighters (GBS, BADD, UAV Relay, Glomo, Submarine SHF Phased Array Antenna, DBC ATD, etc.) • Demonstrate High Throughput (155 Mbps) Tactical Comms Networks (Secure, Survivable Comms Network, DBC ATD, GBS, BADD) • Multiband, Multimode, Wideband, Universal Service, Programmable Radios (Speakeasy) • Bandwidth on Demand for All Warfighters >622 Mbps Between Land Sites >155 Mbps to Cps and Major Ships >64 Kbps to Every Warfighter • Demonstrate 10-Times Data Rate Increase for Selected Areas: e.g., Mobile Cps (Secure, Survivable Communications Networks) • Demonstrate Interoperable, Anti-Jam, Seamless Tactical Comms (DBC ATD, SSCN, etc.) • Develop Advanced, Adaptive Array Antennas	• Enhanced Dissemination Throughput and Connectivity To Meet Most Warfighter Needs • Asymmetric Connectivity To Meet Asymmetric Transaction Requirements: e.g., Global Broadcast With Tactical Internet for Narrower Bandwidth Back-Channel and Cross Linking • High-Capability Tactical Comms Extensions To Serve All Categories of Users • Provide Flexible Radio Communications Services to Users on-the-Move • Initial Phases of Universal Transaction Protocols and Standards, Integrating Across Multimedia Transactions, but Not Yet Totally Oriented on Standardized, Interface-Invariant Content Transactions	• Universal Transaction Protocol Suite To Support Content-Oriented Transactions • Intelligent Conditioning of Transported Information To Match Constraints of Bearer Services and Meet User Demands for Quantity and Form of Presentation • Plain Language Addressing for All Users, Including Mobile and Itinerant • Fully Integrated Asymmetric Services, Including High Throughput, Low Latency Interlinking Across Tactical Networks and Highly Reliable Asymmetric Transaction Protocols • Antijam Protection on Wideband and Asymmetric Networks Derived From Commercial Systems and Services

Important Technical Enhancements Addressed in Current S&T Program

Assurance of Services

1995 TAP Objectives Through 2005	Contribution to Grid Capability Objectives	Remaining Critical Needs
• Dynamic Planning, Monitoring, and Adaptation of Communication Networks; Incorporation of Modeling and Simulation for Environmental Impacts on Communication Networks • Secure Guards, Firewalls, Database Management Systems at B3 Level of Assurance • Multilevel Secure Distributed Computing Clusters at B3 Level of Assurance • Multilevel Secure Object Oriented Global Information System With Integrity and Assured Service • Self-Aware, Reconfigurable, Distributed Computing Environments of Several Hundred Nodes	• Increased Automated Network Management Capabilities • Improved Protection of Information and Systems at the Node, Link, and Transaction Levels • Multilevel Segmenting of Databases and Transactions • Foundations for Self-Aware Grid Adaptation	• Information Warfare C4I Capabilities – Detection and Characterization – Response and Damage Restoral – Integration of IW and Operations • Multilevel Security at the Information Element and Individual User Level – Multiple Access Privileges in Single Transaction or Database Record – Automated Authentication For Individual User and Transaction • Multinational, Multilingual, Multicultural Interoperability • Anticipatory Management of Services – Automated Projections Tied to OPLAN, Current/Projected Situation – Heuristic Development and Appraisal Of Network Management Coas – Projection of Operational Impacts • Improved Ability To Extend High Quality Bearer Services to Tactical Users – Tactical Low Loss, Rugged Fiber – Wideband, Antijam Tactical Comms – Robust Tactical/Mobile Connectivity • Service Assurance and Accountability in Broadcast, Asymmetric, and Intermittent Network Environments

- Operational Context
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Potential Applicability of Commercial Technology Products

	Midterm: ≈ 2005			Long Term: 2010+		
	Infrastructure	Tactical	Coalition	Infrastructure	Tactical	Coalition
Transaction Services:						
Flexible, Nonhierarchical Transport	○	●	●	○	◒	◒
Exchanges Among Heterogeneous Modes and Users	◒	●	●	○	◒	◒
Consistent, Concurrent Dissemination	○	◒	◒	○	◒	◒
Connectivity to and Among Tactical Users		◒	◒		◒	◒
Adaptive Conditioning of Information	●	●	●	◒	●	●
Automatic, Adaptive Addressing	◒	◒	●	○	◒	◒
Flexible, Adaptive Access Control: Infosec, Privileges	●	●	●	●	●	●
Distributed Environment Services:						
Sessions With Heterogeneous Users and Modes	◒	●	●	○	◒	◒
Distributed Processes: Workspaces, Simulations	◒	●	●	○	◒	◒
Knowledge Navigation and Retrieval	◒	●	●	○	◒	◒
Total Grid Knowledge Exploitation	●	●	●	●	●	●
Common, Consistent, Robust Geolocation and Timing	○	◒	◒	○	◒	◒
Massive, Distributed, Heterogeneous Info Management	●	●	●	◒	◒	●
INFOSEC for Distributed Heterogeneous Systems	●	●	●	●	●	●
Assurance of Services:						
Modular Plug-and-Play	◒	◒	●	○	◒	◒
Project Information-Intensive Support Globally	○	◒	◒	○	◒	◒
Visualization of Grid Ability To Support Operations	◒	●	●	○	◒	◒
Responsive Network and System Management	○	◒	●	○	◒	◒
Grid Self-Defense	●	●	●	●	●	●
Multilevel Security	●	●	●	●	●	●
Capability and Hardness in Critical Services	◒	●	●	○	◒	◒

● Largely Unsatisfactory ◒ Partially Satisfactory ○ Largely Satisfactory

Contributions of ACTDs to Grid Capability Enhancement Objectives

Current ACTDs Contributing to Grid Capabilities	Assessment of Contribution to the Grid	Comments
Advanced Joint Planning	F	
Synthetic Theater of War 97	S	
FY96 ACTD Starts That Contribute to Grid Capabilities		
BADD	F	
Combat ID	S	
Joint Logistics	F	
MOBA	M	
Navigation Warfare	M	
FY97 Proposed ACTDs That Contribute to Grid Capabilities		
Cellular Phone Demonstration	S	Can be enhanced if integrated with other networking initiatives
IW Initiative or IW Decision Aids	F	
Aerostats for CMD	S	Can be enhanced if comms relay capability is added
Battlefield Visualization ACTD	S	
Operator/Intelligence Interface	S	
Global Grid	F	
Satellite Control, Data Over ATM/SONET	M	

Key: F – Fully Supportive/Major Contribution S – Somewhat Supportive M – Marginal Contribution

Contributions of Technology Demonstrations to Grid Capability Enhancement

Relevant Demonstrations	Objective FY	Appraised Contribution	Comments
Army:			
Rotorcraft Pilot's Associate ATD	95-99	S*	Potential synergy with BADD
Survivable Adaptive Systems (SAS) ATD	93-95	F	Robust Networking
Combined Arms C2 (CAC2) ATD	94-96	S*	Distributed Environment
Battlespace C2 ATD	97-00	S*	Distrib. Env. & HCI
Battlefield Combat ID ATD	95-96	M*	
Digital Battlefield Communications ATD	95-99	F	Large Multifacet Program
Common Ground Station ATD	95	S*	Multidomain Integration
Crewman's Associate ATD	98	S	
Battlefield Combat ID ATD	96-98	S*	
Total Distribution ATD	94-97	S	Multidomain Integration
Target Acquisition ATD	94-97	M*	
* More fully supportive of Battle Management and/or Sensor-to-Shooter			
Navy:			
Voice/Data Integration	95-96	F	Universal Transactions
Smart Skins Array	96+	F	Tactical Extension of Comms
Submarine Super High Fqcy Phased Array Antenna	96+	F	Single Domain Focus
Littoral Warfare Real-Time EMI Mgmt System	96+	F	Grid Management & Assurance

Key: F – Fully Supportive/Major Contribution S – Somewhat Supportive M – Marginal Contribution

Contributions of Technology Demonstrations to Grid Capability Enhancement

Relevant Demonstrations	Objective FY	Appraised Contribution	Comments
Air Force:			
Expanded Situation Awareness Insertion	95–99	S*	
Speakeasy Multiband Multimode Radio	95–99	F	
Distributed Air Ops Center	95–97	F	Collaborative Agents
Ops/Intell Integration Phase II	95–97	S*	HCI, DCE
JTF Network Control	95–98	F	Coordinate with JCPMS
Reach Back for the Warrior	95–97	F	
Survivable ATM	95–98	F	Adaptive Networks
Hypermedia Integration & Advanced Hypermedia Int.	95–00	S*	Multimode Interfaces
Collaborative Decision Support Demonstration	95–00	M*	
Multiple Database Integration and Update	95–98	S*	Single Domain Focus
Text Exploitation Prototype	95–98	S*	Multimode Interfaces
Update Analysis	95–98	S*	Heterogeneous Environment
Hostile Target Identification	95–97	S*	
Real-Time Application of Intelligence	98–00	S*	Distributed Environment
Real-Time Cueing and ID	97–00	S*	
Target Identification for Tactical Application	96–99	S*	

* More fully supportive of Battle Management and/or Sensor-to-Shooter

Key: F – Fully Supportive/Major Contribution S – Somewhat Supportive M – Marginal Contribution

Functional Capability Enhancement Summary of Goals and Opportunities

Important Capability Enhancement Goals Based on Appraisal of Current Limitations	Adapt Current Systems and Procedures	Implement Available Technology (ACTD)	Long-Term Technology Trends (ATD, R&D, Commercial
Transaction Services:			
Flexible, Nonhierarchical Transport	●	◒	○
Exchanges Among Heterogeneous Modes & Users	●	◒	○
Consistent, Concurrent Dissemination	●	◒	○
Connectivity to and Among Tactical Users	●	◒	◒
Adaptive Conditioning of Information	●	●	◒
Automatic, Adaptive Addressing	●	◒	◒
Flexible, Adaptive Access Control: INFOSEC, Privileges	●	●	◒
Distributed Environment Services:			
Sessions With Heterogeneous Users and Modes	●	◒	○
Distributed Processes: Workspaces, Simulations	◒	◒	○
Knowledge Navigation and Retrieval	●	◒	○
Total Grid Knowledge Exploitation	●	●	◒
Common, Consistent, Robust Geolocation and Timing	●	◒	○
Massive, Heterogeneous, Distributed Info Management	●	●	◒
INFOSEC for Distributed Heterogeneous Systems	●	●	●
Assurance of Services:			
Modular Plug-and-Play	●	◒	○
Project Information-Intensive Support Globally	◒	◒	○
Visualization of Grid Ability To Support Operations	●	◒	◒
Responsive Network and System Management	◒	◒	◒
Grid Self-Defense	●	●	●
Multilevel Security	●	●	◒
Capability and Hardness in Critical Services	◒	◒	○

● Largely Unsatisfactory ◒ Partially Satisfactory ○ Largely Satisfactory

Needs for Additional Demonstrations and Research Emphasis

- C4I for the Grid (No Current ACTD)
  - — Integrate Existing Systems To Allow Control and Visibility of the Grid at the CJTF
  - — Anticipatory Management To Adapt to Fluid Battle Requirements
- Robust Tactical/Mobile Networking (Coordinate With SAS, DBC, and Related Demos)
  - — Smart, Adaptive Transport Networks
  - — Automatic Transaction Conditioning To Match User Needs With Dynamic Network Status
- Defensive IW (Coordinate With Proposed FY97 ACTD)
  - — Detect and Correlate Events Across Multiple Domains
  - — Technologies and Concepts for Real-Time IW C2
- Distributed Situation Assessment (Adjunct to BADD and Battlefield Visualization ACTDs)
  - — Intelligent Agents for Knowledge Discovery and Retrieval in Distributed, Heterogeneous Environments
  - — Distributed Warfighter's Associate To Operate in Conjunction With Users' Warfighters' Associates
- Joint C4I for Rapid Force Projection and Early Entry (No Current ACTD)
  - — Seamless Networking and Distributed Computing To Support In-transit and Initial Entry Operations
  - — Augment Battle Staffs With Automated Reasoning, Uncertainty Management, and Automated Triggers and Alarms for Just-in-Time, Just-Enough Planning
  - — Automated Assistance for Threat/Target Evaluation and Attack
- Information Security (No Current ACTD or ATD)
  - — Multilevel Security With Automated Gateways and Guards for Multinational Applications
  - — MLS at the Info Element and Individual User Levels: Dynamic Element and Aggregate Encryption

- Operational Context
- Broad Concepts
- Important Grid Capabilities
- Mapping of Current S&T Program
- Time Phasing of Operational Demonstrations and Technology Expectations
- Conclusions

Observations on Current Trends Relative to ABIS Objectives

- Communication Systems
- Moving Away From the "Bandwidth Paradigm"
- Approach To Knowledge Management
- Distributed Environments
- Heterogeneity
- Information Warfare Protection
- System Management

Observations on Communication System Trends

- Wideband Communications Initiatives Are Consistent With ABIS Objectives
  - — Movement Toward Wideband SATCOM and Airborne Relay Broadcast to Tactical Users
  - — Movement Toward Asymmetric Bearer Services To Suit Asymmetric Communication Needs
- "Layered" Architecture Requires Greater Emphasis on Robust, Seamless, Secure Networking
  - — Geosynchronous SATCOM, LEO SATCOM, Airborne Relay, Tactical Radio
  - — Gateways With Minimal "Software" Servicing of Transactions
  - — Automatic Network Adaptation and Information Conditioning
  - — Bearer-Independent Transaction Packages: e.g., ATM Cells Through All Media
- Increased Reliance on Commercial Off-the-Shelf Technology Must Be Balanced With IW Protection Features and Risk Management Strategies
  - — Potentially Severe ECM/ESM Vulnerabilities
  - — Potential OPSEC Compromises in Commercial Networks
  - — Vulnerabilities of Commercial Switches and Network Management
  - — Must "Red Team" Commercial Systems Where Appropriate

Observations on Moving Away From the "Bandwidth Paradigm"

- Movement Toward Expanded Throughput Is Consistent With ABIS Concepts and Objectives
  - — Wideband Circuits Extending Into the Tactical Environment
  - — Extension and Rapid Projection of Fiberoptic Circuits
- Limited Movement Toward Intelligent Use of Available Bandwidth
  - — Minimal Use of "Smart End Points" To Reduce Communication Requirements
  - — Lack of Theory and Concepts for Reducing Transactions to Essential Information
  - — Lack of Emphasis on Providing "Good Enough" Condensations and Abstracts
- The Mindset Remains a Major Impediment
  - — The ABIS Concept Immediately Evokes Visions of Terabits Per Second
  - — The Power of the Computer Is Not Generally Viewed As a Potential Mechanism for Reducing Needs for Continuous, Wideband External Inputs of Information

Observations on the Approach to Knowledge Management

- Tools Being Developed To Help Users Deal With Rich Information Environment
  - — Automation To Help Acquire, Integrate, and Present Information
  - — Cognitive Support and Automated Reasoning Tools (AI, Modeling, and Simulation) To Help Use Information
- Initial Steps Being Taken To Integrate Across Observed, Inferred, and Projected Information To Create Knowledge
  - — Automated Intelligent Applications To Define, Track, and Resolve Uncertainties
  - — Automated Tools To Interpret and Extrapolate From Observations
  - — Modeling and Simulation To Project From Current to Future States
- The "Intelligent Network" Is Not Yet Part of Mainstream DoD Vision
  - — Semi-Autonomous, Collaborative, Intelligent Agents To Work With the Nodal Agents and Processes To Find, Integrate, and Provide Knowledge
  - — A "Self-Aware," Self-Adapting Network
  - — Movement of Some Functionality Out of the Nodes and Into the Network
- Total Information Management Is Counter to the Current, Domain-Oriented DoD Culture
  - — Information Tied to Organizations and Applications

Observations on Distributed Environments

- Some Initiatives at Strategic and Operational Levels Are Consistent With ABIS Objectives :
  - — Joint Planning and Force Management Initiatives
  - — Collaborative BDA and Targeting
- Need for Expansion Beyond Current Planning Initiatives:
  - — Distributed, Collaborative Situation Assessment
  - — Distributed, Collaborative Information Management
  - — Distributed, Collaborative ISR Management
- Need for Extension to Tactical Levels
  - — Virtual Workspaces Extended Through Tactical Networks
  - — Services for "Low End" Users on the Move
  - — Asymmetric, Distributed, Collaborative Tactical Environments
- Need for Movement Toward Heterogeneous Environments
  - — Multilingual for Coalition Operations
  - — Different Security Levels and Access Permissions
  - — Mixed Sessions With "High End" and "Low End" Participants

Observations on Heterogeneity

- Long-Term Heterogeneity Not Yet Part of Mainstream DoD Mindset
  - — Emphasis on Commonality and Convergence
  - — Limited Acceptance of Need To Deal With Heterogeneity Outside of DoD Systems Even If Internal Systems Can Be Aligned to COE
  - — Limited Vision of Heterogeneity Across System Generations, Many of Which May Coexist at One Time
- Need to Plan for Dealing With Heterogeneous Environments Through the Use of Common Tools Embedded in the DoD Systems
  - — Basic Interaction Standards and Protocols That Cut Across the Heterogeneous Environments (e.g., TCP/IP, ATM, DCE, CORBA)
  - — Mediators, Brokers, Translators
- Need for Review and Adaptation of DoD Concepts and Policies
  - — An Evolving COE As the Goal Wherever Practical
  - — Defined Objectives To Deal With Heterogeneity Within the Bounds of International Commercial Standards and Practices
  - — Common Tools for Managing Heterogeneity Defined as Essential Parts of the Joint Technical Architecture

Observations on Information Warfare Protection

- Recognition of the Threat Is Appropriate, but Understanding of the Implications Is Not Yet Comprehensive
  - — Acceptance of Severity of Threat
  - — Focus on Implications for Current Types of Systems With "Bastion" Defenses
- Focus Is Mainly on Solving Existing Problems, Not on Creating the Advanced Information System Environment Envisioned for ABIS
  - — Limited Emphasis on Information Security at the Information Element Level, With Model-Based Aggregation
  - — Limited Current Initiative To Address Real-Time, Adaptive, Multilevel Access Control Appropriate for Joint and Combined Operations
- Concepts and Approaches Are Needed To Balance Robustness, Protection, Restoral, and Backup Capabilities
  - — Emphasis on Commercial Products and Services Tends To Ignore Basic Need for Robustness and Protection
  - — Concepts for Information "Leveraging" of the Forces Tend To Overlook Need for Backup Capabilities in the Event of Failure
  - — Emphasis on Capability Overshadows Need for Reliability and Depth of Support

Observations on System Management

- Management of Federated Systems Is Not Being Addressed
  - — Basic "Rules of the Road" Need To Be Developed
- Management of Information Services Is Fragmented Into Independent Domains
  - — User Domains
  - — Functional Domains: Communication Networks, Processing, Information Bases
- Management of Information Services and Other Functional Areas (Operations, ISR, Logistics, and the Like) Is Not Well Coupled
  - — All Functional Areas Need To Be Strongly Linked Within the OPLAN
  - — Interdependencies and Constraints Need To Be Visible
- Management Concept Must Provide for Adequate Warfighting Capability When Distributed Information Systems Are Disrupted
  - — Prepositioning of Information at Warfighter Locations
  - — Sufficient Organic Capability To Continue Operations
  - — Ability to Restore Services

Principal Messages

- The Grid Is an Intelligent, Distributed Information System
  - — Robust, Adaptive Communications
  - — Processing Support for Locating, Integrating, and Delivering Knowledge
- The Grid Is a Federated, Heterogeneous System-of-Systems
  - — Ownership and Management of Information and Services According to the Needs and Prerogatives of the Participants
  - — Functionality Extends to All Types of Users in Joint and Combined Operations
  - — Participants May Include Civil, Commercial, Foreign Organizations
- The Grid Provides Information Services Matched to Tasks and Responsive to the Warfighters' Dynamically Changing Needs
  - — Decoupling of Information Management From Force Management
  - — Adaptation To Support Tactical Task Teams and Other Real-Time Needs
- Information Protection Moves From the Old Paradigm of Risk Avoidance to the New One of Risk Management
  - — Risk Mitigation Balanced With Needs for Functionality and Versatility
  - — C4I and Defense of the Grid Consistent With Projected Operational Environments
  - — Backup and Restoral Consistent With Operational Priorities

Major Challenges

- Evolution of Operational Concepts and Technical Approaches That Respond to the Technology Revolution and the Revolution in Military Affairs
- Graceful Degradation, Backup, and Restoral Capabilities to Ensure Warfighter Essential Levels of Support
- Timely and Orderly Movement From the Current Baseline Systems to the Objective System With Significant Operational Payoff at Each Step
- Balancing Technical and Operational Risk With Potential Payoff and Cost
- Defensive Information Warfare Capabilities
- Management of Federated Systems

Policy Level Issues Needing Emphasis

- Defensive Information Warfare Strategy, Roadmap, and Technology Plan
  - — Appropriate for Joint Staff/OSD Collaborative Effort as Follow-on to ABIS Study
- Clarification of Guidelines, Caveats, and Processes for Applying Commercial Products and Services
  - — Need DoD Policy and Guidance on Risk Management
  - — Need Operational-Technical Red Team To "Calibrate" Systems
- Level of Investment Versus Need for Defensive IW, Information Management, and Services Management
  - — Need for Joint Staff/OSD Review of Current Investments Within Overall Context of C4I Strategy

Implementation Issues Needing Emphasis

- Capabilities and Operational Concepts To Support Tactical Forces on the Move
  - — Wideband, Asymmetric Communications Systems and Applications
  - — Human-Computer Interfaces and Warfighter's Associates
  - — Responsive Network and Services Management
- Coordination of Technical Approaches Across DoD
  - — Convergence Toward Common Long-Term Goals and Approaches
  - — Ability of CONOPS and Technologies To Support Integrated, Joint Operations
- COTS Versus GOTS Versus Development
  - — Cost of Licensing COTS Versus Life Cycle Support for GOTS
  - — Definition of "Good Enough"
- Interoperability Across Legacy Environments and Emerging Systems
  - — Technical Approaches To Provide Forward-Backward Technical Interoperability Without Overconstraining Technology Initiative
  - — Operational Concept Development To Assimilate New Technical Capabilities

Planning and Management Issues Needing Emphasis

- Migration From Current Baseline Systems to ABIS Objective
  - — Roadmap That Addresses Current Inventory Investment, Uninterrupted Military Capability and Readiness, and Rapid Movement Forward, in Pace With Commercial Technology Advances
  - — Life Cycle Support and Training for a Mix of Legacy and Emerging Environments
  - — Restructuring DoD O&M and R&D Expenditures To Reflect Movement Toward Increased Automation
- Effective DoD Participation in Industrial Standards Organizations
  - — Essential To Motivate Accommodation of DoD Needs
  - — Essential To Adapt DoD Programs to Emerging Commercial Capabilities
- Spectrum and Frequency Management
  - — Coping With Continued Commercial Movement Into Formerly Military Parts of the Electromagnetic Spectrum
  - — Coping With "Shared" Spectrum Resources
  - — Total Resource Management for Communications, Sensing, and IW Assets

3. Glossary

ABCC	Airborne Command and Control
ABCCC	Airborne Command and Control Communications
ABIS	Advanced Battlespace Information System
ACTD	Advanced Concept Technology Demonstration
AD	Air Defense
AOC	Air Operations Center
AOR	Area of Responsibility
App	Application (usually refers to automated applications)
ARPA	Advanced Research Projects Agency
ATACMS	Army Tactical Missile System
ATD	Advanced Technology Demonstration
ATM	Asynchronous Transfer Mode
ATO	Air Tasking Order
ATR	Automated Target Recognition
AWACS	Airborne Warning and Control System
B-ISDN	Broadband Integrated Services Digital Network
BADD	Battlefield Awareness and Data Dissemination
BDA	Battle Damage Assessment
BM	Battle Management
bpp	Bits Per Pixel
C2	Command and Control
C2I	Command, Control, and Intelligence
C2W	Command and Control Warfare
C4I	Command, Control, Communications, Computers, and Intelligence
C4ISR	Command, Control, Communication, Computers, Intelligence, Surveillance, and Reconnaissance
CDC	Combat Direction Center
CEC	Cooperative Engagement Concept
CEOI	Communications and Electronics Operating Instruction

CINC	Commander-in-Chief
CJTF	Commanders, Joint Task Force
CMA	Collection Management Authority
CMW	Compartmented Mode Workstation
COA	Course(s) of Action
COE	Common Operating Environment
CONOPS	Concept of Operations
CONUS	Continental United States
CORBA	Common Object Request Broker Architecture
COTS	Commercial Off the Shelf
CP	Command Post
CVW	Collaborative Virtual Workspace
DBC	Digital Battlefield Communications
DBMS	Database Management System
DCE	Distributed Computing Environment
DDR&E	Director, Defense Research and Engineering
DISA	Defense Information Systems Agency
DMS	Defense Message System
DSP	Defense Support Program
DTAP	Defense Technology Area Program
DTO	Defense Technology Objective
ECCM	Electronic Counter-Countermeasures
ECM	Electronic Countermeasures
ELINT	Electronic Intelligence
EMI	Electromagnetic Interference
EO	Electro-Optical
ESM	Electronic Support Measures
FLIR	Forward Looking Infrared

FST	Fire Support Team
FTX	Field Training Exercise
GBS	Global Broadcast System
GOTS	Government Off the Shelf
HAE UAV	High-Altitude Endurance Unmanned Aerial Vehicle
HCI	Human-Computer Interface
HTACC	Hardened Tactical Air Command Center
IAW	In Accordance With
ID	Identity or Identification
IFF	Identification, Friend or Foe
IMINT	Imagery Intelligence
Infosec	Information Security
IP	Internet Protocol
IPB	Intelligence Preparation of the Battlefield
IR	Infrared
ISAR	Inverse Synthetic Aperture Radar
ISDN	Integrated Services Digital Network
ISR	Intelligence, Surveillance, Reconnaissance
IT	Information Technology
ITO	Integrated Tasking Order
IW	Information Warfare
JBC	Joint Battle Center
JCPMS	Joint Communications Planning and Management System
JFACC	Joint Force Air Component Commander
JFC	Joint Forces Commander
JFLCC	Joint Force Land Component Commander
JFMCC	Joint Force Maritime Component Commander
JIC	Joint Intelligence Center
JIT	Just in Time

JPEG	Joint Photographic Experts Group (Standard)
JROC	Joint Requirements Overnight Council
JSTARS	Joint Surveillance and Target Acquisition Radar System
JTF	Joint Task Force
JWCA	Joint Warfighting Capability Assessment
KCOIC	Korean Command Operations/Intelligence Center
LRC	Lesser Regional Conflict
M&S	Modeling and Simulation
MASINT	Measurements and Signatures Intelligence
MC&G	Mapping, Cartography, and Geodesy
MILSATCOM	Military Satellite Communications
MLRS	Multiple Launch Rocket System
MLS	Multilevel Security
MMW	Millimeter Wave
MOE	Measure of Effectiveness
MRC	Major Regional Conflict
MRL	Multiple Rocket Launcher
MTI	Moving Target Indicator
NRT	Near Real-Time
NTM	National Technical Means
O&M	Operations and Maintenance
OIW	Operations/Intelligence Workstation
OPLAN	Operation Plan
OPSEC	Operations Security
OTAR	Over-the-Air Rekeying
OTH	Over the Horizon
PGM	Precision Guided Weapon
POM	Program Objective Memorandum
RDT&E	Research, Development, Test, and Engineering

REECE	Reconnaissance
RMA	Revolution in Military Affairs
ROE	Rules of Engagement
RT	Real-Time
S&T	Science and Technology
SA	Situational Awareness
SAR	Synthetic Aperture Radar
SAS	Survivable, Adaptable System
SATCOM	Satellite Communications
SIGINT	Signals Intelligence
SOF	Special Operations Force
SONET	Synchronous Optical Network
SSCN	Secure, Survivable Communications Network
STS	Sensor-to-Shooter
TAC	Tactical Air Controller
TAP	Technology Area Program
TBM	Theater Ballistic Missile
TCP	Transaction Communications Protocol (used with IP)
TCT	Time-Critical Target
TEL	Transportable Erectable Launcher
TFCC	Task Force Command and Control
TLAM	Tomahawk Land Attack Missile
TOC	Tactical Operations Center
TOT	Time Over (or On) Target
UAV	Unmanned Aerial Vehicle
VCJCS	Vice Chairman Joint Chiefs of Staff
VTC	Video Teleconference

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